# FINAL

## Intrinsic Remediation Treatability Study Addendum for Site ST-29

**Patrick Air Force Base**
**Florida**

**Prepared For**

**Air Force Center for Environmental Excellence**
**Technology Transfer Division**
**Brooks Air Force Base, Texas**
**San Antonio, Texas**



**and**

**Patrick Air Force Base**
**Florida**

**September 1999**

# PARSONS

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14 September 1999

Mr. Jerry Hansen
Technical Program Manager
AFCEE/ERT
3207 North Road, Bldg. 532
Brooks AFB, TX 78235-5363

Subject: Responses to AFCEE Comments on the Draft Intrinsic Remediation Treatability Study for Site ST-29, Patrick AFB, Florida (Contract F41624-92-D-8036-0025)

Dear Mr. Hansen:

Enclosed please find two copies of the September 1999 Final Intrinsic Remediation Treatability Study (TS) for Site ST-29, Patrick AFB, Florida. This report was prepared by Parsons Engineering Science, Inc. (Parsons ES) for the Air Force Center for Environmental Excellence Technology Transfer Division (AFCEE/ERT) and Patrick Air Force Base (AFB).

The intent of the TS Addendum was to determine the role of natural attenuation in remediating fuel contamination in groundwater at Site ST-29. The draft TS Addendum was submitted to AFCEE in July 1999. Comments on the draft TS Addendum were received from AFCEE as reviewed by Jon Atkinson (dated 09 September 1999). Responses to these comments were prepared by Parsons ES and are attached to this letter.

If you have any questions or comments regarding this package, please do not hesitate to contact me at (303) 831-8100.

Sincerely,

PARSONS ENGINEERING SCIENCE, INC.

Bruce M. Henry

Bruce M. Henry, P.G.
Project Manager

Enclosures
c.c. Mr. Ed Worth – Patrick AFB (two copies)
Mr. Don Kampbell – USEPA NRMRL (two copies)

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**Responses to AFCEE Comments on the Draft Addendum to the Intrinsic Remediation Treatability Study for Site ST-29, Patrick AFB, Florida**

## GENERAL COMMENTS

Comment 1) Page 5, Sec 2.0, Para 1, Sent 1: Manganese is listed but does not appear on Table 1A. This apparent discrepancy should be resolved.

Parsons ES Response: *Manganese was not analyzed for in January 1996. Section 2.0 will be amended to indicate that manganese was only analyzed for in 1998.*

Comment 2) Pages 5 and 6, Tables 1A and 1B: For the analyte "Alkalinity," the typo "Biocarbonate" should be corrected.

Parsons ES Response: *The tables will be corrected as indicated.*

Comment 3) Page 13, Table 4: Here, and throughout the document (e.g., p. 18, para 1) recommend reporting all analytical results to no more than three significant figures (e.g., 1,860 ug/L of toluene) to better reflect accuracy and certainty of these measurements.

Parsons ES Response: *Analytical results will be reported to three significant figures throughout the document.*

Comment 4) Page 16, Fig 3: For the January 1996 BTEX plume, the highest mapped concentration (50 ug/L) is two orders of magnitude lower than the highest mapped concentration (5,000 ug/L) for the other three depicted plumes. This apparent discrepancy should be resolved.

Parsons ES Response: *Agreed. Insufficient data was collected in January 1996 to determine the maximum BTEX concentrations within the groundwater plume (e.g., no data for monitoring point cluster CPT-03). Based on maximum concentrations of BTEX measured in 1994, 1995, and 1998, dashed (inferred) BTEX isopleths for 500 ug/L and 5,000 ug/L will be added to the January 1996 map.*

Comment 5) Page 20, Sec 2.2, Para 3: Recommend annotating the computer codes (e.g., BIOPLUME II, MODFLOW) that were used in the computer modeling efforts.

Parsons ES Response: *The computer code for BIOPLUME II was used in the modeling effort for the TS, and will be annotated in Section 2.2.*

**Responses to AFCEE Comments on the Draft Addendum to the Intrinsic Remediation Treatability Study for Site ST-29, Patrick AFB, Florida (Continued)**

Comment 6) Page 21, Sec 2.3, Line 11: Recommend changing "may indicated" to "may indicate."

Parsons ES Response: *The text will be changed as indicated.*

Comment 7) Page 35, Sec 2.5, Para 1, Line 4: "sulfate" should be replaced by "methane."

Parsons ES Response: *The text will be changed as indicated.*

# FINAL
# ADDENDUM TO THE
# INTRINSIC REMEDIATION TREATABILITY STUDY FOR SITE ST-29

**AT**

**PATRICK AIR FORCE BASE**
**FLORIDA**

**September 1999**

**Prepared for:**

**AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE**
**BROOKS AIR FORCE BASE**
**SAN ANTONIO, TEXAS**

**AND**

**PATRICK AIR FORCE BASE**
**FLORIDA**

**Prepared by:**

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**Denver, Colorado 80290**

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## LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| µg/L | micrograms per liter |
| AFB | Air Force Base |
| AFCEE | Air Force Center for Environmental Excellence |
| AFESC | Air Force Engineering and Services Center |
| AST | aboveground storage tank |
| bgs | below ground surface |
| BTEX | benzene, toluene, ethylbenzene, and xylenes |
| $CaCO_3$ | calcium carbonate |
| CVOCs | chlorinated volatile organic compounds |
| DO | dissolved oxygen |
| ES | Engineering-Science, Inc. |
| ESE | Environmental Science & Engineering, Inc. |
| FAC | Florida Administrative Code |
| FDEP | Florida Department of Environmental Protection |
| $Fe^{2+}$ | ferrous iron |
| $Fe^{3+}$ | ferric iron |
| ft/day | feet per day |
| ft/ft | foot/foot |
| ft amsl | feet mean sea level |
| ft/yr | feet per year |
| IRP | Installation Restoration Program |
| LTM | long-term monitoring |
| mg/L | milligrams per liter |
| MOGAS | motor vehicle gasoline |
| MTBE | methyl tertiary-butyl ether |
| mV | millivolts |
| NRMRL | National Risk Management Research Laboratory |
| ORP | oxidation/reduction potential |
| Parsons ES | Parsons Engineering Science, Inc. |
| PCA | Petroleum Contamination Assessment |
| ppmv | parts per million, volume per volume |
| SVE | soil vapor extraction |
| TMBs | trimethylbenzenes |
| TOC | total organic carbon |
| TS | Treatability Study |
| TVPH | total volatile petroleum hydrocarbons |
| USEPA | US Environmental Protection Agency |
| UST | underground storage tank |

## 1.0 INTRODUCTION

This report was prepared for the Air Force Center for Environmental Excellence (AFCEE) by Parsons Engineering Science, Inc. (Parsons ES) as an addendum to the *Final Intrinsic Remediation Treatability Study (TS) for Site ST-29, Patrick Air Force Base (AFB), Florida (Parsons ES, 1995).* The TS was conducted to evaluate the use of intrinsic remediation with long-term monitoring (LTM) for remediation of fuel hydrocarbon contamination dissolved in groundwater at Site ST-29. The Final TS included data for two sampling events conducted in March 1994 and March 1995. This addendum summarizes the results of two additional sampling events conducted in January 1996 and March 1998 by researchers from the US Environmental Protection Agency (USEPA) National Risk Management Research Laboratory (NRMRL) Subsurface Protection and Remediation Division. Additional data collected by CH2M Hill in May 1995 also are included in this analysis.

The main emphasis of this summary is to evaluate changes in dissolved benzene, toluene, ethylbenzene, and xylene (BTEX) concentrations, BTEX plume extent, and natural attenuation mechanisms through time. Results, calculations, and predictions presented in the TS (Parsons ES, 1995) are used as the basis for comparison. Data collected in January 1996 and March 1998 are presented in Appendix A.

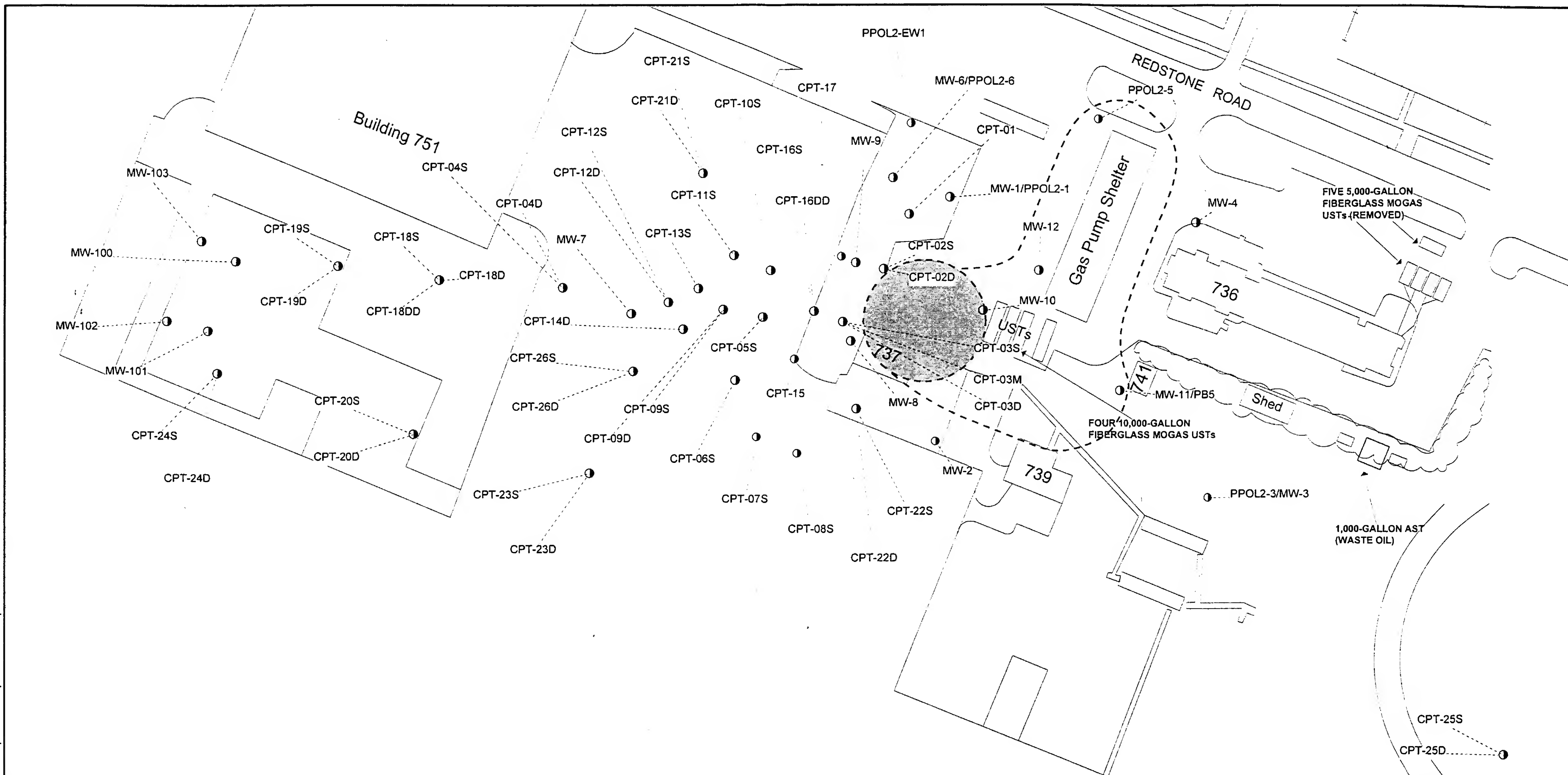
### 1.1 Facility Background

Patrick AFB lies on a narrow barrier island off the eastern coast of Florida in Brevard County. Site ST-29 is located in the north-central section of Patrick AFB, approximately 400 feet west of the northeastern end of the northeast/southwest runway. Site ST-29 consists of the BX Service Station, including a small food market (Building 736), a gasoline dispensing area, and a car wash facility (Building 737) (Figure 1). The BX Service Station has been in operation since 1954. Four 10,000-gallon fiberglass motor vehicle gasoline (MOGAS) underground storage tanks (USTs) and one 1,000-gallon waste oil aboveground storage tank (AST) are currently used to dispense or store petroleum products.

### 1.2 Operational and Site Investigation History

In 1973, five 5,000-gallon MOGAS USTs previously located northeast of Building 736 (the BX Service Station) were removed (Figure 1), and the excavations were backfilled with sand. In the same year, the MOGAS tanks were replaced with five 10,000-gallon fiberglass USTs. One of the 10,000-gallon MOGAS USTs and product lines from another of the 10,000-gallon fiberglass USTs were discovered to be leaking in 1985. Between 1985 and 1986, an estimated 700 gallons of unleaded gasoline was released into the subsurface as a result of the leaking lines and tank. In 1986, the leaking 10,000-gallon MOGAS UST was removed, leaving four MOGAS USTs in operation. A 500-gallon waste oil UST also was removed and replaced in February 1992 with a 1,000-gallon waste oil AST.

The Air Force Installation Restoration Program (IRP) was initiated at Patrick AFB in 1984 when the Air Force Engineering and Services Center (AFESC) retained




## LEGEND

| | |
|---|---|
| MW-8 | Monitoring Location ID |
| UST | Underground Storage Tank |
| AST | Aboveground Storage Tank |
| MOGAS | Motor Vehicle Gasoline |

Pilot-Scale Bioventing Area

Expanded Scale Bioventing Area

0 40 80
Feet

FIGURE 1

**SITE MAP**

Site ST-29
Intrinsic Remediation Treatability Study Addendum
Patrick Air Force Base, Florida

**PARSONS ENGINEERING SCIENCE, INC.**
Denver, Colorado

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Environmental Science & Engineering, Inc. (ESE) to conduct a records search of previous Base activities (Phase I of the IRP) (ESE, 1984). Phase II (stage 1) IRP work at Patrick AFB began in 1985 and the BX Service Station (ST-29) was identified and added to the IRP for Phase II (stage 2) activities (ESE, 1988). Phase II (stage 2) work involved two monitoring events (November 1988 to January 1989 and October to November 1989) to determine fluctuations in groundwater levels at the site (ESE, 1991). A Phase II (stage 3) program at the BX Service Station was performed by O'Brien & Gere Engineers, Inc. (1992) in accordance with the Florida Department of Environmental Protection (FDEP) Petroleum Contamination Assessment (PCA) guidelines, as outlined in Chapters 17-770.600 and 17-770.630 of the Florida Administrative Code (FAC). The objective of the Phase II (stage 3) investigation was to evaluate the nature and extent of contamination at the site and to make remedial recommendations.

A soil gas survey was conducted by Engineering-Science, Inc (ES, now Parsons ES) at the BX Service Station in January 1993 (ES, 1993), prior to installation of a pilot bioventing system. A 20-foot by 20-foot grid was laid out in the area where previous sampling had determined that soil hydrocarbon contamination was present. Total volatile petroleum hydrocarbons (TVPH) exceeded 10,000 parts per million, volume per volume (ppmv) at locations adjacent to the north and east sides of the car wash (Building 737) at Site ST-29.

### 1.3 Remedial Activities

A pilot scale bioventing system consisting of one horizontal vent well and five soil gas monitoring points was installed and tested at the site in March 1993. The pilot-scale bioventing system was installed in an area north of Building 737 (Figure 1) to treat soil contaminated with residual BTEX. Due to high levels of TVPH in soil gas, a soil vapor extraction (SVE) pilot test was performed from October 1993 to January 1994. The pilot-scale air injection bioventing system was then run from January 1994 through July 1995. The pilot-scale system was expanded with a full-scale bioventing system in June 1995. The full-scale bioventing system was in operation at the site from June 1995 to July 1998, at which time confirmation sampling was performed. Based on results of the confirmation sampling, it was recommended that the bioventing system operation be discontinued. Details regarding the results of the bioventing system were presented in a confirmation sampling and analysis report (Parsons ES, 1999).

## 2.0 RESULTS

In January 1996 and March 1998, researchers from the USEPA NRMRL collected groundwater samples from 13 and 14 monitoring locations, respectively at Site ST-29. Locations CPT-4S, -4D, -09S, -12S, -16DD, -18S were sampled during both the January 1996 and March 1998 events.

Samples were analyzed in the field for oxidation/reduction potential (ORP), dissolved oxygen (DO), conductivity, temperature, pH, carbon dioxide, manganese (1998 only), sulfide and alkalinity. Additional sample volume was analyzed at the USEPA NRMRL in Ada, Oklahoma for nitrate+nitrite, ammonia, chloride, sulfate, methane, ethane, ethene, total organic carbon (TOC), BTEX, trimethylbenzenes (TMBs), and methyl tert-butyl

ether (MTBE). Samples were also analyzed for total fuel carbon, phenols and aliphatic acids, and chlorinated volatile organic compounds (CVOCs) in 1996. CVOCs were not detected in any groundwater samples collected in January 1996. The analytical methods used in January 1996 and March 1998 are summarized in Tables 1A and 1B. Copies of laboratory results and field notes are provided in Appendix A.

### 2.1 Flow Direction and Gradient

Depth to groundwater was measured at monitoring locations in March 1994 and January 1996. Groundwater elevations were not recorded in March/May 1995 or March 1998. Monitoring point construction details are summarized in Table 2, and groundwater elevation data collected at the site are summarized in Table 3. Groundwater elevation contour maps for March 1994 and January 1996 are shown on Figure 2.

Shallow groundwater at Site ST-29 is present at depths of 4 to 5 feet below ground surface (bgs). Groundwater at Site ST-29 generally flows to the west towards the Banana River (Parsons ES, 1995). The horizontal hydraulic gradient measured in March 1994 was approximately 0.002 foot per foot (ft/ft), with an average groundwater velocity calculated to be 0.43 foot per day (ft/day), or 157 feet per year (ft/yr). The water table in January 1996 was an average of 0.4 feet higher than in March 1994. The January 1996 data suggest a northwesterly groundwater flow direction. However, insufficient data were collected to accurately determine the flow direction and gradient during this sampling event.

Vertical hydraulic gradients measured in nested monitoring point pairs in 1994 range from approximately 0.004 ft/ft in a downward direction at CPT-22 and CPT-03, to approximately 0.0015 to 0.0123 ft/ft in an upward direction at CPT-04, CPT-26, and CPT-24. No vertical gradients were present at CPT-23 and CPT-25 in 1994. This information indicates the presence of a downward hydraulic gradient in or near the source area, with a transition to an upward gradient to the west of the source area in March 1994. A similar downward vertical gradient was observed in January 1996 at CPT-03, but the vertical gradient at CPT-04 shifted from upward in 1994 to downward in 1996.

### 2.2 Dissolved BTEX Contamination

Analytical results for fuel hydrocarbons detected at the site are provided in Table 4. In order to evaluate trends in dissolved BTEX concentrations and distribution through time, the areal distributions of dissolved BTEX for March 1994, March 1995, January 1996, and March 1998 are presented on Figure 3. Vertical distributions along the primary flow path of dissolved BTEX for each sampling event are presented on Figure 4. As defined by the 5 microgram per liter (μg/L) concentration isopleth, the March 1998 BTEX plume appears to be approximately 450 feet long, compared to approximately 650 feet long in March 1994 (Figure 3). Given an advective groundwater velocity of approximately 156 ft/yr and an estimated retardation coefficient for benzene of 2.6 (Parsons ES, 1995), the plume potentially could have migrated a minimum of 240 feet in the four years from March 1994 to March 1998 (not accounting for the effects of dispersion, which would elongate the plume even further). However, monitoring data indicate that the plume extents for March/May 1995, January 1996, and March 1998 are less than March 1994.

**TABLE 1A**
**SUMMARY OF GROUNDWATER ANALYTICAL METHODS**
**JANUARY 1996**
**INTRINSIC REMEDIATION TREATABILITY STUDY ADDENDUM**
**SITE ST-29**
**PATRICK AFB, FLORIDA**

| Analyte | Method | Field (F) or Fixed-Base Laboratory (L) |
|---|---|---|
| Oxidation\Reduction Potential | Direct Reading Meter | F |
| Dissolved Oxygen | Direct Reading Meter | F |
| Conductivity | Direct Reading Meter | F |
| Temperature | Direct Reading Meter | F |
| pH | Direct Reading Meter | F |
| Ferrous Iron | Colorimetric, Hach Method 8146 or equivalent | F |
| Hydrogen Sulfide | Colorimetric, Hach Method 8131 or equivalent | F |
| Alkalinity (Carbonate [$CO_3^{2-}$] and Bicarbonate [$HCO_3^-$]) | Titrimetric, Hach Method 8221 or equivalent | F |
| Nitrate + Nitrite | EPA Method 353.1 | L |
| Conductivity | EPA Method 120.1 | L |
| Sulfate | Waters Capillary Electrophoresis Method N-601 | L |
| Methane, Ethane and Ethene | RSKSOP-175[a/] and RSKSOP-147 | L |
| Total Organic Carbon | RSKSOP-102 | L |
| BTEX[b/], TMBs[c/], and Total Fuel Carbon | RSKSOP-133 | L |
| CVOCs[d/], MTBE[e/], and 1,2-Dibromoethane | RSKSOP-148 | L |
| Phenols and Aliphatic Acids | RSKSOP-177 | L |

[a/] RSKSOP = Robert S. Kerr Laboratory (now known as NRMRL) standard operating procedure.
[b/] BTEX = benzene, toluene, ethylbenzene, and xylenes.
[c/] TMBs = trimethylbenzenes.
[d/] CVOCs = chlorinated volatile organic compounds.
[e/] MTBE = methyl tertiary-butyl ether.

# TABLE 1B
# SUMMARY OF GROUNDWATER ANALYTICAL METHODS
# MARCH 1998
## INTRINSIC REMEDIATION TREATABILITY STUDY ADDENDUM
## SITE ST-29
## PATRICK AFB, FLORIDA

| Analyte | Method | Field (F) or Fixed-Base Laboratory (L) |
|---|---|---|
| Oxidation\Reduction Potential | Direct Reading Meter | F |
| Dissolved Oxygen | Direct Reading Meter | F |
| Conductivity | Direct Reading Meter | F |
| Temperature | Direct Reading Meter | F |
| pH | Direct Reading Meter | F |
| Ferrous Iron | Colorimetric, Hach Method 8146 or equivalent | F |
| Carbon Dioxide | Titrimetric, Hach Method 1436-01 or equivalent | F |
| Manganese | Colorimetric, HACH Method 8034, or equivalent | F |
| Sulfide | Colorimetric, Hach Method 8131 or equivalent | F |
| Alkalinity (Carbonate [$CO_3^{2-}$] and Bicarbonate [$HCO_3^-$]) | Titrimetric, Hach Method 8221 or equivalent | F |
| Nitrate + Nitrite | Lachat FIA Mehod 10-107-04-2-A | L |
| Ammonia | Lachat FIA Mehod 10-107-06-1 | L |
| Chloride | Waters Capillary Electrophoresis Method N-601 | L |
| Sulfate | Waters Capillary Electrophoresis Method N-601 | L |
| Methane, Ethane and Ethene | RSKSOP-175[a/] and RSKSOP-194 | L |
| Total Organic Carbon | RSKSOP-102 | L |
| BTEX[b/], TMBs[c/], and MTBE[d/] | RSKSOP-122 | L |

[a/] RSKSOP = Robert S. Kerr Laboratory (now known as NRMRL) standard operating procedure.

[b/] BTEX = benzene, toluene, ethylbenzene, and xylenes.

[c/] TMBs = trimethylbenzenes.

[d/] MTBE = methyl tertiary-butyl ether.

## TABLE 2
## MONITORING POINT CONSTRUCTION SUMMARY[a/]
### INTRINSIC REMEDIATION TREATABILITY STUDY ADDENDUM
### SITE ST-29
### PATRICK AFB, FLORIDA

| Well Location ID | Easting | Northing | Ground Elevation (ft amsl)[b/] | Total Depth (ft btoc)[c/] | Bottom of Well (ft amsl) | Top of Screen (ft bgs)[d/] | Top of Screen (ft amsl) | Bottom of Screen (ft bgs) | Bottom of Screen (ft amsl) | Screen Midpoint (ft amsl) |
|---|---|---|---|---|---|---|---|---|---|---|
| CPT-01 | 1423363 | 626491 | 7.02 | 8.28 | -1.26 | 5.00 | 2.02 | 8.28 | -1.26 | 0.38 |
| CPT-02D | 1423346 | 626455 | 7.07 | 13.42 | -6.35 | 10.14 | -3.07 | 13.42 | -6.35 | -4.71 |
| CPT-02S | 1423346 | 626455 | 7.07 | 7.65 | -0.58 | 4.37 | 2.70 | 7.65 | -0.58 | 1.06 |
| CPT-03D | 1423319 | 626420 | 6.55 | 19.04 | -12.49 | 15.76 | -9.21 | 19.04 | -12.49 | -10.85 |
| CPT-03M | 1423319 | 626420 | 6.55 | 14.10 | -7.55 | 10.82 | -4.27 | 14.10 | -7.55 | -5.91 |
| CPT-03S | 1423319 | 626420 | 6.55 | 7.87 | -1.32 | 4.59 | 1.96 | 7.87 | -1.32 | 0.32 |
| CPT-04D | 1423133 | 626443 | 6.57 | 11.54 | -4.97 | 8.26 | -1.69 | 11.54 | -4.97 | -3.33 |
| CPT-04S | 1423133 | 626443 | 6.57 | 9.92 | -3.35 | 6.64 | -0.07 | 9.92 | -3.35 | -1.71 |
| CPT-05S | 1423266 | 626423 | 6.26 | 8.00 | -1.74 | 4.72 | 1.54 | 8.00 | -1.74 | -0.10 |
| CPT-06S | 1423248 | 626381 | 6.26 | 8.00 | -1.74 | 4.72 | 1.54 | 8.00 | -1.74 | -0.10 |
| CPT-07S | 1423235 | 626354 | 6.36 | NA[e/] | NA | NA | NA | NA | NA | NA |
| CPT-08S | 1423262 | 626343 | 6.48 | 8.00 | -1.52 | 4.72 | 1.76 | 8.00 | -1.52 | 0.12 |
| CPT-09D | 1423240 | 626428 | 6.35 | 15.00 | -8.65 | 11.72 | -5.37 | 15.00 | -8.65 | -7.01 |
| CPT-09S | 1423240 | 626428 | 6.35 | 8.00 | -1.65 | 4.72 | 1.63 | 8.00 | -1.65 | -0.01 |
| CPT-10S | 1423271 | 626454 | 6.26 | 8.00 | -1.74 | 4.72 | 1.54 | 8.00 | -1.74 | -0.10 |
| CPT-11S | 1423247 | 626464 | 6.37 | 8.00 | -1.63 | 4.72 | 1.65 | 8.00 | -1.63 | 0.01 |
| CPT-12D | 1423203 | 626433 | 6.43 | 16.00 | -9.57 | 12.72 | -6.29 | 16.00 | -9.57 | -7.93 |
| CPT-12S | 1423203 | 626433 | 6.43 | 8.00 | -1.57 | 4.72 | 1.71 | 8.00 | -1.57 | 0.07 |
| CPT-13S | 1423223 | 626442 | 6.41 | 17.49 | -11.08 | 14.21 | -7.80 | 17.49 | -11.08 | -9.44 |
| CPT-14D | 1423213 | 626415 | 6.36 | 16.73 | -10.37 | 13.45 | -7.09 | 16.73 | -10.37 | -8.73 |
| CPT-16DD | 1423300 | 626427 | 6.14 | 45.00 | -38.86 | 41.72 | -35.58 | 45.00 | -38.86 | -37.22 |
| CPT-16S | 1423300 | 626427 | 6.14 | 8.00 | -1.86 | 4.72 | 1.42 | 8.00 | -1.86 | -0.22 |
| CPT-18D | 1423051 | 626448 | 6.58 | 16.00 | -9.42 | 12.72 | -6.14 | 16.00 | -9.42 | -7.78 |
| CPT-18DD | 1423051 | 626448 | 6.58 | 40.00 | -33.42 | 36.72 | -30.14 | 40.00 | -33.42 | -31.78 |
| CPT-18S | 1423051 | 626448 | 6.58 | 8.00 | -1.42 | 4.72 | 1.86 | 8.00 | -1.42 | 0.22 |
| CPT-19D | 1422983 | 626457 | 6.39 | 16.00 | -9.61 | 12.72 | -6.33 | 16.00 | -9.61 | -7.97 |
| CPT-19S | 1422983 | 626457 | 6.39 | 8.00 | -1.61 | 4.72 | 1.67 | 8.00 | -1.61 | 0.03 |

022/729691/PATRICK/2.xls TABLE 2

# TABLE 2 (Continued)
## MONITORING POINT CONSTRUCTION SUMMARY[a]
### INTRINSIC REMEDIATION TREATABILITY STUDY ADDENDUM
### SITE ST-29
### PATRICK AFB, FLORIDA

| Well Location ID | Easting | Northing | Ground Elevation (ft amsl)[b] | Total Depth (ft btoc)[c] | Bottom of Well (ft amsl) | Top of Screen (ft bgs)[d] | Top of Screen (ft amsl) | Bottom of Screen (ft bgs) | Bottom of Screen (ft amsl) | Screen Midpoint (ft amsl) |
|---|---|---|---|---|---|---|---|---|---|---|
| CPT-20D | 1423034 | 626345 | 6.40 | 16.00 | -9.60 | 12.72 | -6.32 | 16.00 | -9.60 | -7.96 |
| CPT-20S | 1423034 | 626345 | 6.40 | 8.00 | -1.60 | 4.72 | 1.68 | 8.00 | -1.60 | 0.04 |
| CPT-21D | 1423226 | 626518 | 6.49 | 15.30 | -8.81 | 12.02 | -5.53 | 15.30 | -8.81 | -7.17 |
| CPT-21S | 1423226 | 626518 | 6.49 | 8.00 | -1.51 | 4.72 | 1.77 | 8.00 | -1.51 | 0.13 |
| CPT-22D | 1423328 | 626362 | 6.75 | 13.45 | -6.70 | 10.17 | -3.42 | 13.45 | -6.70 | -5.06 |
| CPT-22S | 1423328 | 626362 | 6.75 | 8.05 | -1.30 | 4.77 | 1.98 | 8.05 | -1.30 | 0.34 |
| CPT-23D | 1423151 | 626319 | 6.57 | 13.50 | -6.93 | 10.22 | -3.65 | 13.50 | -6.93 | -5.29 |
| CPT-23S | 1423151 | 626319 | 6.57 | 7.00 | -0.43 | 3.72 | 2.85 | 7.00 | -0.43 | 1.21 |
| CPT-24D | 1422903 | 626386 | 5.89 | 13.00 | -7.11 | 9.72 | -3.83 | 13.00 | -7.11 | -5.47 |
| CPT-24S | 1422903 | 626386 | 5.89 | 6.50 | -0.61 | 3.22 | 2.67 | 6.50 | -0.61 | 1.03 |
| CPT-25D | 1423761 | 626129 | 6.60 | 13.00 | -6.40 | 9.72 | -3.12 | 13.00 | -6.40 | -4.76 |
| CPT-25S | 1423761 | 626129 | 6.60 | 6.50 | 0.10 | 3.22 | 3.38 | 6.50 | 0.10 | 1.74 |
| CPT-26D | 1423180 | 626387 | 6.47 | 13.50 | -7.03 | 10.22 | -3.75 | 13.50 | -7.03 | -5.39 |
| CPT-26S | 1423180 | 626387 | 6.47 | 7.00 | -0.53 | 3.72 | 2.75 | 7.00 | -0.53 | 1.11 |
| MW-1/PPOL2-1 | 1423390 | 626502 | 6.92 | 13.40 | NA | NA | NA | NA | NA | NA |
| MW-2 | NA | NA | NA | 13.40 | NA | NA | NA | NA | NA | NA |
| MW-4 | NA | NA | NA | 12.30 | NA | NA | NA | NA | NA | NA |
| MW-5 | NA | NA | NA | 12.70 | NA | NA | NA | NA | NA | NA |
| MW-6/PPOL2-6 | 1423352 | 626515 | 6.39 | 54.90 | NA | NA | NA | NA | NA | NA |
| MW-11/PB5 | NA | NA | 7.39 | 15.45 | -8.06 | NA | NA | NA | NA | NA |
| PPOL2-5 | NA | NA | NA | 12.51 | NA | NA | NA | NA | NA | NA |

[a] Construction summary data is not available for the following wells: MW-3,-7,-8,-9,-10,-12,-100,-101,-102,-103.

[b] ft amsl = feet above mean sea level.

[c] ft btoc = feet below top of casing.

[d] ft bgs = feet below ground surface.

[e] NA = not available.

# TABLE 3
## GROUNDWATER ELEVATION DATA
### INTRINSIC REMEDIATION TREATABILITY STUDY ADDENDUM
### SITE ST-29
### PATRICK AFB, FLORIDA

| Sample Location | Datum [a] Elevation (ft amsl)[b] | Sample Date | Depth to Water (ft btoc)[c] | Groundwater Elevation (ft amsl) |
|---|---|---|---|---|
| CPT-02S | 6.61 | 3/27/1994 | 4.93 | 1.68 |
| | | 1/30/1996 | 4.48 | 2.13 |
| CPT-03S | 6.26 | 3/27/1994 | 4.57 | 1.69 |
| | | 1/30/1996 | 4.11 | 2.15 |
| CPT-03D | 6.23 | 3/27/1994 | 4.59 | 1.64 |
| | | 1/30/1996 | 4.16 | 2.07 |
| CPT-04S | 5.99 | 3/27/1994 | 4.46 | 1.53 |
| | | 1/30/1996 | 4.06 | 1.93 |
| CPT-04D | 6.01 | 3/27/1994 | 4.46 | 1.55 |
| | | 1/30/1996 | 4.11 | 1.90 |
| CPT-09S | 6.13 | 3/27/1994 | 4.35 | 1.78[d] |
| | | 1/30/1996 | 4.00 | 2.13 |
| CPT-12S | 5.90 | 3/27/1994 | 4.40 | 1.50 |
| | | 1/30/1996 | 4.06 | 1.84 |
| CPT-16DD | NA[e] | 1/30/1996 | 3.86 | NA |
| CPT-18S | 6.11 | 3/27/1994 | 4.69 | 1.42 |
| | | 1/30/1996 | 4.38 | 1.73 |
| CPT-18DD | NA | 1/30/1996 | 4.55 | NA |
| CPT-22S | 6.35 | 3/27/1994 | 4.50 | 1.85 |
| CPT-22D | 6.32 | 3/27/1994 | 4.49 | 1.83 |
| CPT-23S | 5.94 | 3/27/1994 | 4.30 | 1.64 |
| CPT-23D | 5.84 | 3/27/1994 | 4.20 | 1.64 |
| CPT-24S | 5.49 | 3/27/1994 | 4.52 | 0.97 |
| CPT-24D | 5.44 | 3/27/1994 | 4.46 | 0.98 |
| CPT-25S | 6.43 | 3/27/1994 | 5.66 | 0.77 |
| CPT-25D | 6.49 | 3/27/1994 | 5.72 | 0.77 |
| CPT-26S | 5.89 | 3/27/1994 | 4.25 | 1.64[d] |
| CPT-26D | 5.79 | 3/27/1994 | 4.13 | 1.66 |
| MW-1/PPOL2-1 | 7.47 | 3/25/1994 | 5.33 | 2.14 |
| MW-6/PPOL2-6 | 6.64 | 3/25/1994 | 4.93 | 1.71 |
| MW-11/PB5 | 10.86 | 3/23/1994 | 8.75 | 2.11 |
| PPOL2-5 | 7.48 | 3/25/1994 | 5.36 | 2.12 |

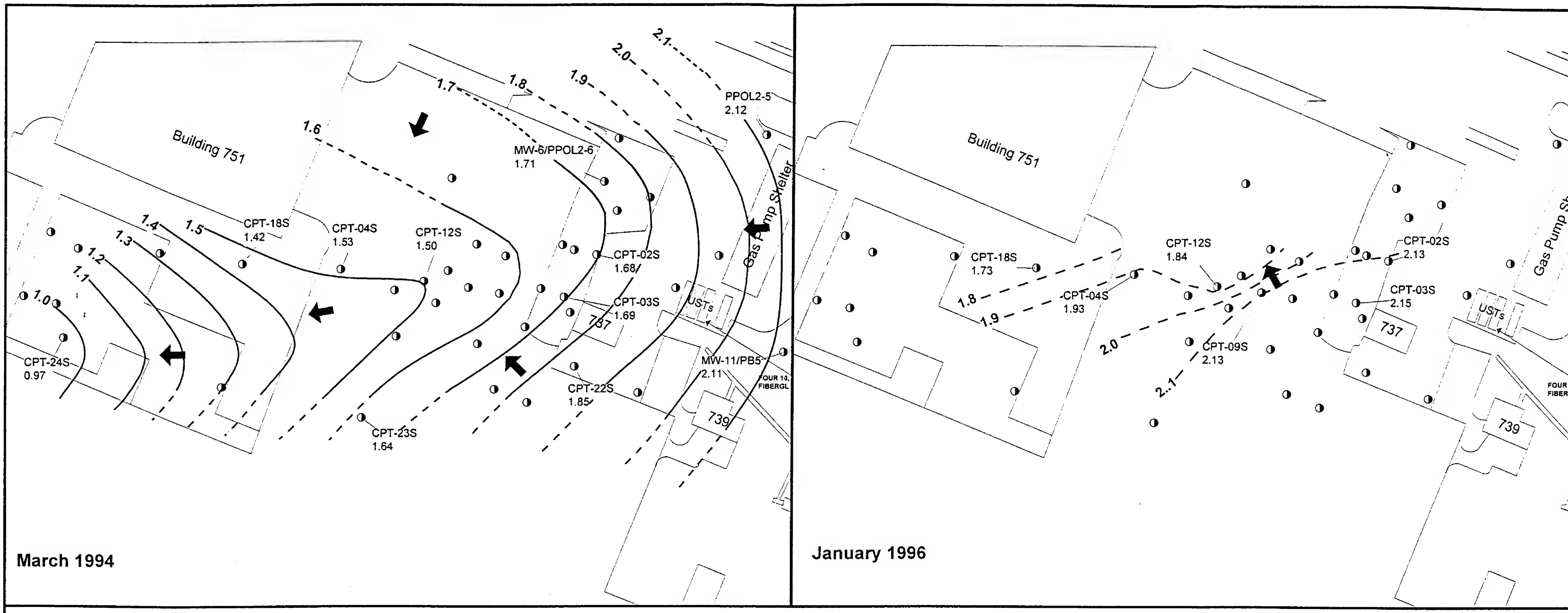
[a] Datum is top of well casing.

[b] ft amsl = feet above mean sea level.

[c] ft btoc = feet below top of casing.

[d] Data are suspect and not used for contouring groundwater elevations.

[e] NA = not available.




## LEGEND

| | |
|---|---|
| CPT-4S 1.53 | Monitoring Well/Point and Water Table Elevation in Feet Above Mean Sea Level (ft amsl) |
| 1.5 | Water Table Elevation Contour (ft amsl) |
| | Inferred Direction of Groundwater Flow |
| MOGAS | Motor Vehicle Gasoline |
| UST | Underground Storage Tank |

NOTE: Elevation contours are based on the shallowest screened interval at monitoring well/point pairs.

0 60 120
Feet

N

FIGURE 2

GROUNDWATER ELEVATIONS

Site ST-29
Intrinsic Remediation Treatability Study Addendum
Patrick Air Force Base, Florida

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado



FILE NAME: 022\ES\REMED\BIOPLUME\PATRICK\ST-29\MAPINFO\FILES\REPORT-WS\GWELEV.WOR 7/14/99

## TABLE 4
## FUEL HYDROCARBON COMPOUNDS DETECTED IN GROUNDWATER
### INTRINSIC REMEDIATION TREATABILITY STUDY ADDENDUM
### SITE ST-29
### PATRICK AFB, FLORIDA

| Sample Location | Sample Date | Benzene (µg/L)[d] | Toluene (µg/L) | Ethylbenzene (µg/L) | p-Xylene (µg/L) | m-Xylene (µg/L) | o-Xylene (µg/L) | Total Xylene (µg/L) | Total BTEX[a] (µg/L) | 1,3,5 TMB[b] (µg/L) | 1,2,4 TMB (µg/L) | 1,2,3 TMB (µg/L) | Fuel Carbon (µg/L) | MTBE[c] (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CPT-01 | Mar-94 | <1 [e] | 2.42 | <1 | <1 | <1 | <1 | <1 | 2.42 | <1 | <1 | <1 | NA [f] | NA |
| CPT-02S | Mar-94 | 375 | 18.9 | 165 | 166 | 353 | 119 | 638 | 1,200 | 71.2 | NA | 86.3 | NA | NA |
| | Mar-95 | 167 | 6.25 | 133 | 95.7 | 156 | 8.58 | 260 | 566 | 44.0 | 203 | 89.2 | NA | NA |
| | Mar-95 (Dup) [g] | 156 | 6.37 | 135 | 107 | 168 | 9.36 | 285 | 583 | 48.0 | 202 | 90.0 | NA | NA |
| | Jan-96 | 64.3 | 5.20 | 53.3 | 4.40 | 8.40 | 3.50 | 16.3 | 139 | 1.50 | 45.5 | 37.9 | 1,500 | 514 |
| CPT-02D | Mar-94 | 1.50 | 1.70 | 1.10 | 1.40 | 2.60 | 1.40 | 5.40 | 9.70 | <1 | NA | 1.30 | NA | NA |
| CPT-03S | Mar-94 | 724 | 737 | 823 | 1,220 | 2,410 | 1,390 | 5020 | 7,304 | 347 | NA | 403 | NA | NA |
| | Mar-95 | 1,500 | 1,530 | 2,250 | 2,860 | 3,470 | 2,500 | 8,820 | 14,100 | 777 | 2,900 | 851 | NA | NA |
| | Jan-96 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 101 |
| | Jan-96 (Dup) | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 128 |
| | Mar-98 | 692 | 1,860 | 3,960 | 5,150 | 6,470 | 4,320 | 15,900 | 22,450 | 1,250 | 4,860 | 942 | NA | <1 |
| CPT-03M | Mar-94 | 207 | 15.6 | 40.5 | 42.2 | 24.0 | 7.50 | 73.7 | 337 | 2.80 | NA | 16.0 | NA | NA |
| | Mar-95 | 134 | 14.0 | 21.8 | 58.2 | 32.4 | 32.1 | 123 | 293 | 7.75 | 30.7 | 18.6 | NA | NA |
| | Jan-96 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 7.60 |
| | Mar-98 | 215 | 240 | 1,050 | 1,510 | 1,060 | 1,040 | 3,610 | 5,110 | 374 | 1,590 | 276 | NA | 3.50 |
| CPT-03D | Mar-94 | 1.80 | 1.10 | <1 | <1 | 1.40 | <1 | 1.40 | 4.30 | <1 | NA | <1 | NA | NA |
| | Mar-95 | 31.0 | <1 | 10.5 | 22.5 | 2.96 | 1.39 | 26.8 | 68.3 | 1.40 | 1.97 | 2.87 | NA | NA |
| | Mar-95 (Dup) | 30.3 | 0.99 | 10.4 | 17.8 | 1.12 | 2.05 | 21.0 | 62.6 | 1.42 | 1.64 | 3.26 | NA | NA |
| | Jan-96 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 15.9 |
| | Mar-98 | 1.50 | <1 | <1 | <1 | <1 | ND[h] | <1 | 1.50 | <1 | <1 | <1 | NA | <1 |
| CPT-04S | Mar-94 | <1 | 6.00 | <1 | <1 | <1 | <1 | <1 | 6.00 | <1 | <1 | <1 | NA | NA |
| | Mar-95 | <1 | 0.97 | <1 | 1.06 | 1.22 | 1.30 | 3.58 | 4.55 | 1.27 | ND | 1.84 | NA | NA |
| | Mar-95 (Dup) | <1 | ND | <1 | <1 | 0.99 | ND | 0.99 | 0.99 | ND | 1.70 | 1.42 | NA | NA |
| | Jan-96 | ND | ND | <1 | <1 | <1 | <1 | <1 | ND | ND | ND | ND | <1 | 1.40 |
| | Mar-98 | <1 | <1 | 3.70 | 3.20 | 2.20 | <1 | 5.40 | 9.10 | <1 | 1.80 | <1 | NA | 1.20 |
| CPT-04D | Mar-94 | <1 | 3.70 | <1 | <1 | <1 | <1 | <1 | 3.70 | <1 | <1 | <1 | NA | NA |
| | Mar-95 | <1 | 1.00 | <1 | 1.06 | 1.13 | 1.35 | 3.54 | 4.54 | 1.11 | ND | 1.98 | NA | NA |
| | Jan-96 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | 53.3 |
| | Mar-98 | 1.30 | 2.30 | ND | 1,170 | ND | 4.80 | 1,180 | 1,180 | 2.00 | 10.2 | 1.80 | NA | 2.50 |
| CPT-05S | Mar-94 | <1 | 1.20 | <1 | <1 | <1 | <1 | <1 | 1.20 | <1 | NA | <1 | NA | NA |
| CPT-06S | Mar-94 | <1 | 11.1 | <1 | 1.30 | 2.30 | <1 | 3.60 | 14.7 | <1 | NA | <1 | NA | NA |
| CPT-07S | Mar-94 | <1 | 3.90 | <1 | <1 | 1.00 | <1 | 1.00 | 4.90 | <1 | NA | <1 | NA | NA |
| CPT-08S | Mar-94 | <1 | 2.80 | <1 | <1 | <1 | <1 | <1 | 2.80 | <1 | <1 | <1 | NA | NA |
| CPT-09S | Mar-94 | 2.00 | 4.00 | <1 | <1 | <1 | <1 | <1 | 6.00 | <1 | <1 | <1 | NA | NA |
| | Mar-95 | 1.09 | <1 | 1.29 | 1.82 | 1.73 | 1.45 | 5.00 | 7.38 | 1.09 | 2.46 | 3.60 | NA | NA |
| | Jan-96 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| | Mar-98 | <1 | ND | <1 | <1 | <1 | <1 | <1 | ND | ND | ND | <1 | NA | 2.80 |

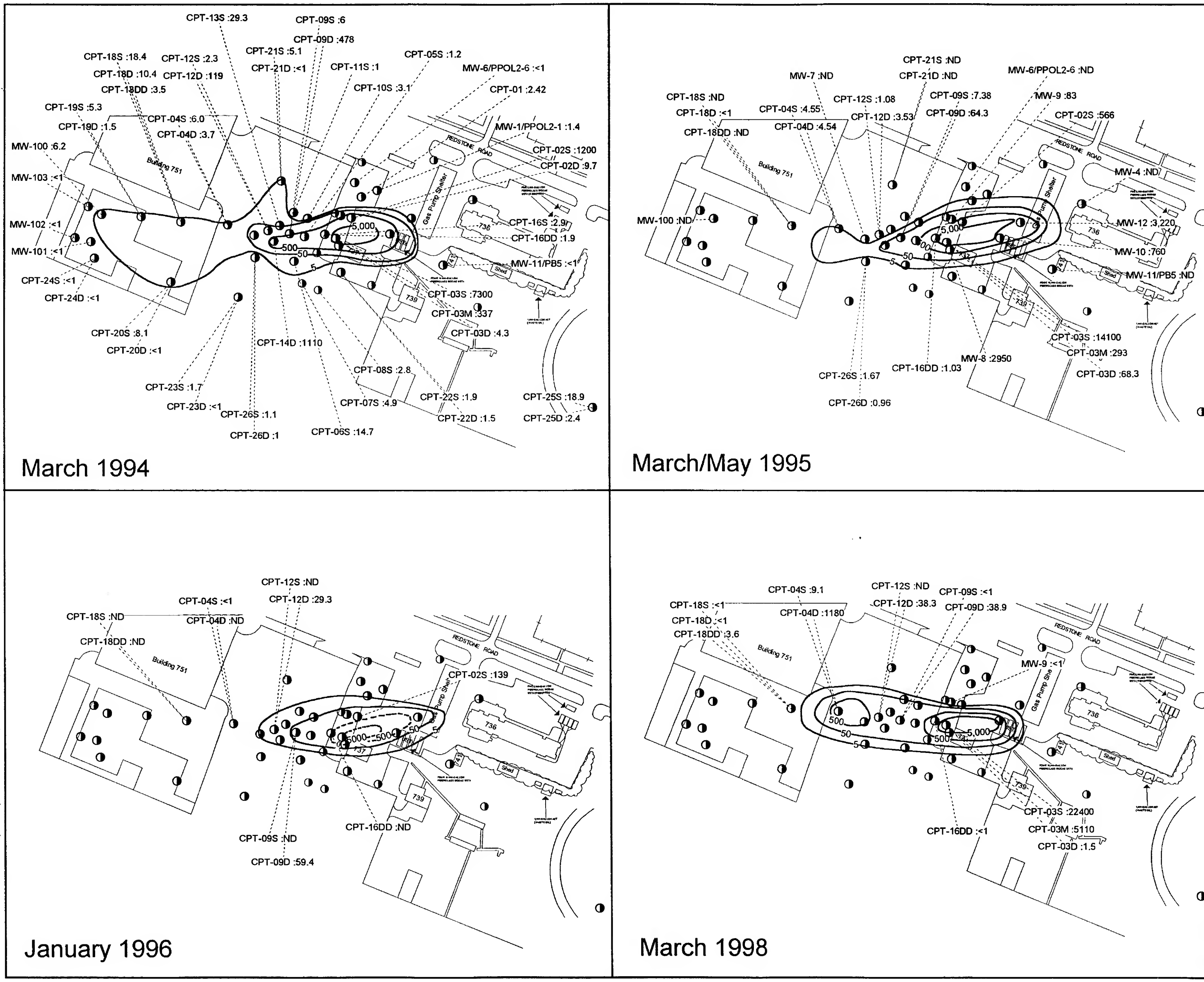
## TABLE 4 (Continued)
## FUEL HYDROCARBON COMPOUNDS DETECTED IN GROUNDWATER
### INTRINSIC REMEDIATION TREATABILITY STUDY ADDENDUM
### SITE ST-29
### PATRICK AFB, FLORIDA

| Sample Location | Sample Date | Benzene (µg/L)[d] | Toluene (µg/L) | Ethylbenzene (µg/L) | p-Xylene (µg/L) | m-Xylene (µg/L) | o-Xylene (µg/L) | Total Xylene (µg/L) | Total BTEX[a] (µg/L) | 1,3,5 TMB[b] (µg/L) | 1,2,4 TMB (µg/L) | 1,2,3 TMB (µg/L) | Fuel Carbon (µg/L) | MTBE[c] (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CPT-09D | Mar-94 | 427 | 14.1 | 2.90 | 11.7 | 12.1 | 9.70 | 33.5 | 478 | <1 | NA | 9.40 | NA | NA |
| | Mar-95 | 44.8 | 4.35 | 0.98 | 4.81 | 4.01 | 5.36 | 14.2 | 64.3 | 1.38 | 1.45 | 7.26 | NA | NA |
| | Jan-96 | 28.9 | 10.4 | 1.90 | 6.20 | 5.50 | 6.50 | 18.2 | 59.4 | 1.20 | 1.20 | 7.80 | 914 | 353 |
| | Mar-98 | 14.1 | 6.90 | <1 | 4.40 | 7.50 | 6.00 | 17.9 | 38.9 | <1 | 1.20 | 5.80 | NA | 31.3 |
| CPT-10S | Mar-94 | <1 | 3.10 | <1 | <1 | <1 | <1 | <1 | 3.10 | <1 | <1 | <1 | NA | NA |
| CPT-11S | Mar-94 | <1 | 1.00 | <1 | <1 | <1 | <1 | <1 | 1.00 | <1 | <1 | <1 | NA | NA |
| CPT-12S | Mar-94 | <1 | 1.10 | <1 | <1 | 1.20 | <1 | 1.20 | 2.30 | <1 | NA | <1 | NA | NA |
| | Mar-95 | <1 | ND | <1 | <1 | 1.08 | <1 | 1.08 | 1.08 | ND | ND | 1.27 | NA | NA |
| | Jan-96 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| | Mar-98 | ND | ND | ND | <1 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| CPT-12D | Mar-94 | 93.5 | 5.90 | <1 | 8.40 | 7.00 | 3.70 | 19.1 | 119 | <1 | NA | 4.10 | NA | NA |
| | Mar-95 | <1 | <1 | <1 | 1.21 | 1.33 | 0.99 | 3.53 | 3.53 | 1.15 | 1.33 | 2.75 | NA | NA |
| | Jan-96 | 5.00 | 5.20 | ND | 8.90 | 5.20 | 5.00 | 19.1 | 29.3 | <1 | 1.60 | 5.40 | 625 | 348 |
| | Mar-98 | 5.00 | 6.80 | <1 | 14.9 | 6.70 | 4.90 | 26.5 | 38.3 | <1 | <1 | 4.10 | NA | 68.4 |
| CPT-13S | Mar-94 | <1 | 8.40 | <1 | 10.4 | 5.40 | 3.10 | 18.9 | 29.3 | <1 | NA | 6.70 | NA | NA |
| CPT-14D | Mar-94 | 960 | 16.6 | 11.5 | 39.2 | 36.8 | 44.2 | 120 | 1,110 | 15.3 | NA | 23.0 | NA | NA |
| CPT-16S | Mar-94 | 1.00 | 1.90 | <1 | <1 | <1 | <1 | <1 | 2.90 | <1 | <1 | <1 | NA | NA |
| CPT-16DD | Mar-94 | <1 | 1.90 | <1 | <1 | <1 | <1 | <1 | 1.90 | <1 | <1 | <1 | NA | NA |
| | Mar-95 | <1 | <1 | <1 | <1 | 1.03 | <1 | 1.03 | 1.03 | ND | ND | ND | NA | NA |
| | Jan-96 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| | Mar-98 | ND | ND | <1 | <1 | <1 | <1 | <1 | ND | ND | <1 | ND | NA | ND |
| CPT-18S | Mar-94 | <1 | 1.70 | 2.30 | 3.80 | 6.60 | 4.00 | 14.4 | 18.4 | 1.40 | NA | 1.60 | NA | NA |
| | Mar-95 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | NA | NA |
| | Jan-96 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| | Mar-98 | ND | ND | <1 | <1 | <1 | ND | <1 | ND | ND | <1 | ND | NA | ND |
| CPT-18D | Mar-94 | 8.30 | 2.10 | <1 | <1 | <1 | <1 | <1 | 10.4 | <1 | <1 | <1 | NA | NA |
| | Mar-95 | ND | ND | ND | <1 | <1 | ND | <1 | ND | ND | ND | ND | NA | NA |
| | Mar-98 | <1 | <1 | 1.20 | 1.30 | 1.10 | <1 | 2.40 | 3.60 | ND | <1 | ND | NA | ND |
| CPT-18DD | Mar-94 | <1 | 3.50 | <1 | <1 | <1 | <1 | <1 | 3.50 | <1 | <1 | <1 | NA | NA |
| | Mar-95 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | NA | NA |
| | Jan-96 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| CPT-19S | Mar-94 | <1 | <1 | 1.10 | 1.50 | 2.70 | <1 | 4.20 | 5.30 | <1 | NA | <1 | NA | NA |
| CPT-19D | Mar-94 | 1.50 | <1 | <1 | <1 | <1 | <1 | <1 | 1.50 | <1 | <1 | <1 | NA | NA |
| CPT-20S | Mar-94 | <1 | 2.10 | <1 | 1.50 | 2.70 | 1.80 | 6.00 | 8.10 | <1 | NA | 1.00 | NA | NA |
| CPT-20D | Mar-94 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | ND | <1 | <1 | <1 | NA | NA |

## TABLE 4 (Concluded)
## FUEL HYDROCARBON COMPOUNDS DETECTED IN GROUNDWATER
### INTRINSIC REMEDIATION TREATABILITY STUDY ADDENDUM
### SITE ST-29
### PATRICK AFB, FLORIDA

| Sample Location | Sample Date | Benzene (µg/L)[d] | Toluene (µg/L) | Ethylbenzene (µg/L) | p-Xylene (µg/L) | m-Xylene (µg/L) | o-Xylene (µg/L) | Total Xylene (µg/L) | Total BTEX[a] (µg/L) | 1,3,5 TMB[b] (µg/L) | 1,2,4 TMB (µg/L) | 1,2,3 TMB (µg/L) | Fuel Carbon (µg/L) | MTBE[c] (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CPT-21S | Mar-94 | NA | 5.10 | <1 | <1 | <1 | <1 | <1 | 5.10 | <1 | NA | <1 | NA | NA |
| | Mar-95 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | NA | NA |
| CPT-21D | Mar-94 | NA | <1 | <1 | <1 | <1 | <1 | <1 | ND | <1 | <1 | <1 | NA | NA |
| | Mar-95 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | NA | NA |
| CPT-22S | Mar-94 | NA | 1.90 | <1 | <1 | <1 | <1 | <1 | 1.90 | <1 | <1 | <1 | NA | NA |
| CPT-22D | Mar-94 | 1.50 | <1 | <1 | <1 | <1 | <1 | <1 | 1.50 | <1 | <1 | <1 | NA | NA |
| CPT-23S | Mar-94 | <1 | <1 | <1 | <1 | 1.70 | <1 | 1.70 | 1.70 | <1 | NA | <1 | NA | NA |
| CPT-23D | Mar-94 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | ND | <1 | <1 | <1 | NA | NA |
| CPT-24S | Mar-94 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | ND | <1 | <1 | <1 | NA | NA |
| CPT-24D | Mar-94 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | ND | <1 | <1 | <1 | NA | NA |
| CPT-25S | Mar-94 | <1 | 2.10 | 2.30 | 4.10 | 6.90 | 3.50 | 14.5 | 18.9 | 1.70 | NA | 1.50 | NA | NA |
| CPT-25D | Mar-94 | <1 | 1.00 | <1 | <1 | 1.40 | <1 | 1.40 | 2.40 | <1 | NA | <1 | NA | NA |
| MW-1/PPOL | Mar-94 | <1 | <1 | <1 | <1 | 1.40 | <1 | 1.40 | 1.40 | <1 | <1 | <1 | NA | NA |
| MW-4 | May-95 | ND | ND | ND | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA |
| MW-6/PPOL | Mar-94 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | ND | <1 | <1 | <1 | NA | NA |
| MW-6 | May-95 | ND | ND | ND | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA |
| MW-7 | May-95 | ND | ND | ND | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA |
| MW-8 | May-95 | 140 | 85.0 | 270 | NA | NA | NA | 2,450 | 2,950 | NA | NA | NA | NA | NA |
| MW-9 | May-95 | 37.0 | ND | 46.0 | NA | NA | NA | NA | 83.0 | NA | NA | NA | NA | NA |
| | Mar-98 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | ND | <1 | <1 | <1 | NA | ND |
| | Mar-98 (Dup) | <1 | ND | <1 | <1 | <1 | <1 | <1 | ND | <1 | <1 | <1 | NA | ND |
| MW-10 | May-95 | 180 | ND | 360 | NA | NA | NA | NA | 540 | NA | NA | NA | NA | NA |
| MW-11/PB5 | Mar-94 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | ND | <1 | <1 | <1 | NA | NA |
| | May-95 | ND | ND | ND | NA | NA | NA | NA | ND | NA | NA | NA | NA | NA |
| MW-12 | Mar-94 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | ND | <1 | <1 | <1 | NA | NA |
| | May-95 | 210 | ND | 700 | NA | NA | NA | 2,310 | 3,220 | NA | NA | NA | NA | NA |
| MW-100 | Mar-94 | 4.10 | <1 | <1 | 1.10 | 1.00 | <1 | 2.10 | 6.20 | <1 | <1 | <1 | NA | NA |
| | Mar-95 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | NA | NA |
| MW-101 | Mar-94 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | ND | <1 | <1 | <1 | NA | NA |
| MW-102 | Mar-94 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | ND | <1 | <1 | <1 | NA | NA |
| MW-103 | Mar-94 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | ND | <1 | <1 | <1 | NA | NA |

[a] BTEX = Benzene, Toluene, Ethylbenzene, and Xylenes.
[b] TMB = Trimethylbenzene.
[c] MTBE = Methyl tert-butyl ether.
[d] µg/L = micrograms per liter.
[e] <1 = Below limit of quantitation (1 µg/L).
[f] NA = Data not available or sample not analyzed for this parameter.
[g] Dup = Duplicate Sample.
[h] ND = Compound not detected at the method detection limit.




## LEGEND

| | |
|---|---|
| MW-8 : 2,950 | Monitoring Location ID and Dissolved BTEX Concentration (micrograms per liter) |
| 50 | Dissolved BTEX Concentration Isopleth (Dashed where inferred) |
| ND | Not Detected |
| <1 | Reported Value Less than Specified Quantitation Limit |
| UST | Underground Storage Tank |
| AST | Aboveground Storage Tank |
| MOGAS | Motor Vehicle Gasoline |

0 100 200

Feet

N

FIGURE 3

**DISSOLVED BTEX IN GROUNDWATER**

Site ST-29

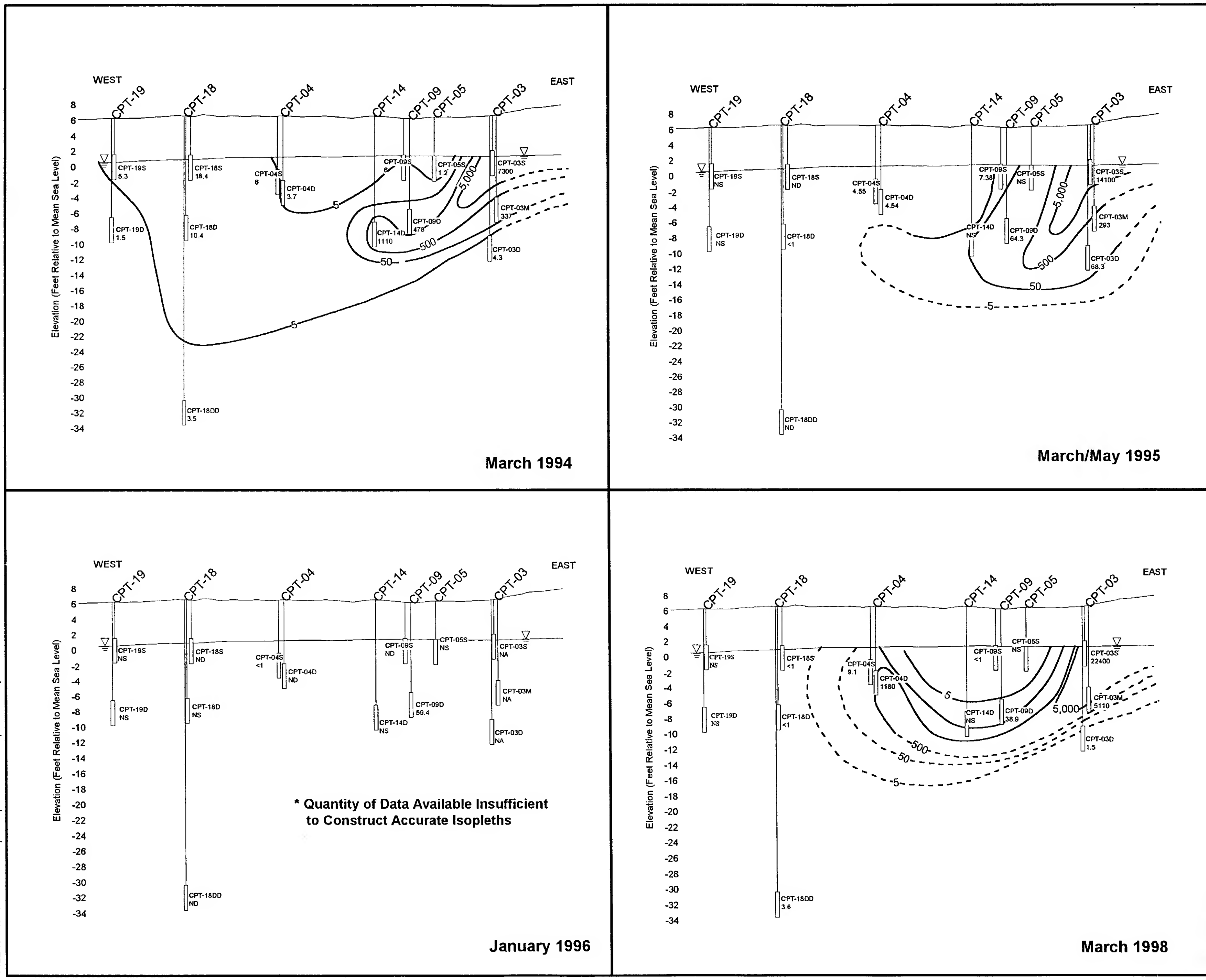
Intrinsic Remediation Treatability Study Addendum

Patrick Air Force Base, Florida

**PARSONS ENGINEERING SCIENCE, INC.**

Denver, Colorado

FILE NAME: s:\es\remed\bioplume\patrick\st-29\mapinfofiles\report-ws\btex.wor 9/13/99




## LEGEND

CPT-4S Monitoring Location ID
1.53 Concentration of Dissolved BTEX (micrograms per liter)

1.5 Dissolved BTEX Concentration Isopleth (Dashed where inferred)

ND Not Detected

NS Not Sampled

Approximate Groundwater Surface

0 50 100
Feet

FIGURE 4

**CROSS-SECTION OF DISSOLVED BTEX IN GROUNDWATER**

Site ST-29
Intrinsic Remediation Treatability Study Addendum
Patrick Air Force Base, Florida

**PARSONS ENGINEERING SCIENCE, INC.**
Denver, Colorado

FILE NAME: s:es/remed/bioplume/patrick/st-29/mapinfofiles/report-ws/XBTEX.WOR 9/13/99

Plume shrinkage provides strong evidence supporting the occurrence of biodegradation, particularly along the perimeter of the plume.

The cross-sectional representations of the total BTEX plume in Figure 4 show the changes in vertical and horizontal distribution of the plume along the primary flow path between 1994 and 1998. Due to the limited data available for January 1996, no contour lines are presented for this date. The total BTEX concentration at CPT-04D has increased from 1.2 µg/L in 1994 to 1,180 µg/L in 1998, indicating downgradient migration of the plume core (Figure 4). The plume core appears to travel beneath monitoring points CPT-09D and CPT-14D before migrating upward toward CPT-04D.

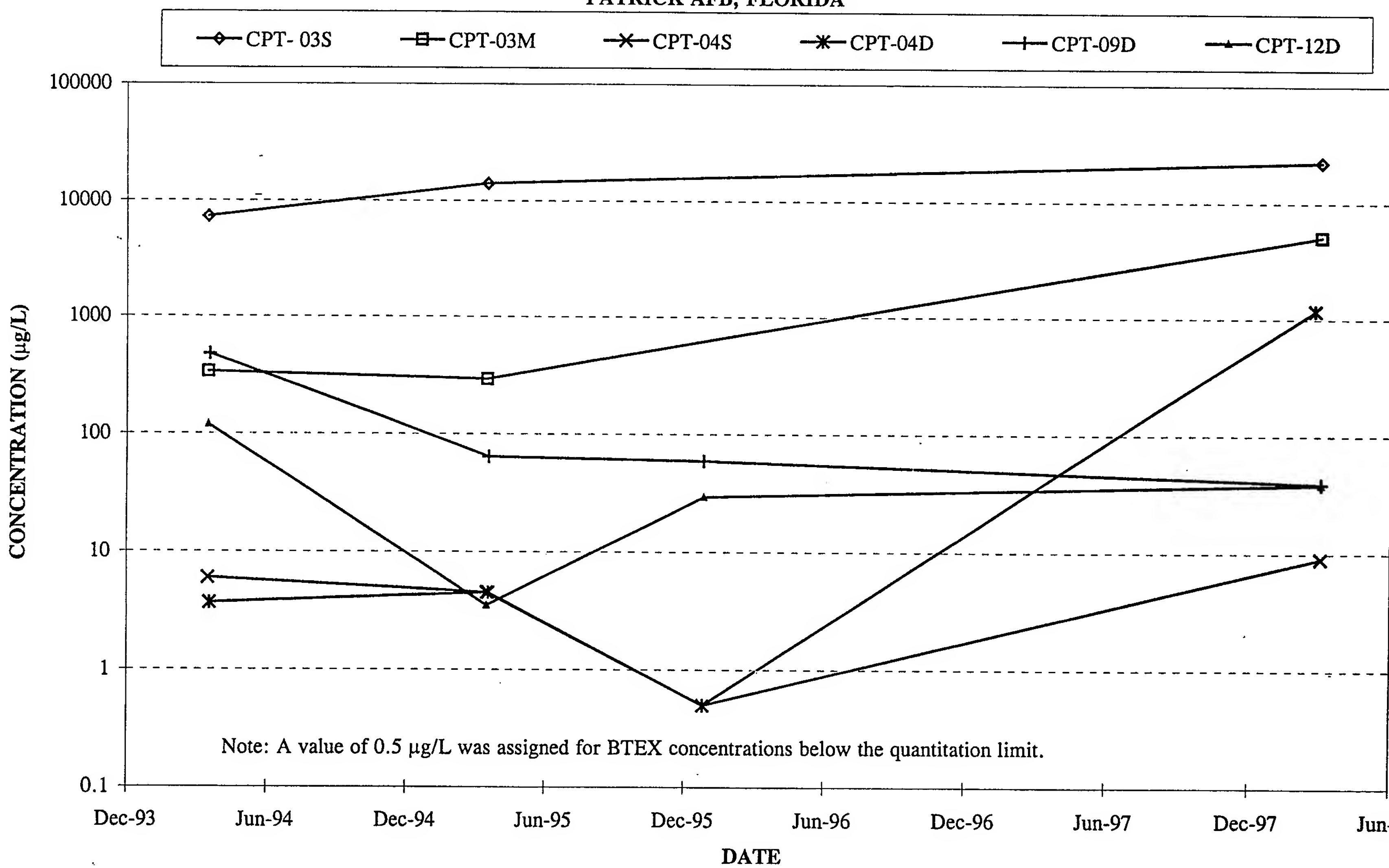
The vertical extent of the March 1998 BTEX plume is defined near the source area by the well screen intervals of monitoring cluster CPT-03. Groundwater sampled from CPT-03D decreased in BTEX concentration from 68.3 µg/L to 1.5 µg/L between March 1995 and March 1998. The vertical extent of the BTEX plume appears to be decreasing in the area of CPT-03, although monitoring points at CPT-03 were not sampled during January 1996. The vertical extent of the BTEX plume in the downgradient direction is indicated by the monitoring point cluster at CPT-18. While low concentrations (less than or equal to 3.6 µg/L) of BTEX have been detected in CPT-18DD, BTEX concentrations at CPT-18S and CPT-18D were not detected in 1998.

Figure 5 is a plot of temporal changes in dissolved BTEX concentrations in monitoring points sampled along the approximate longitudinal centerline of the dissolved BTEX plume. Figure 5 illustrates that dissolved BTEX concentrations have increased from 1994 to 1998 along the center line of the plume at monitoring points CPT-03S, CPT-03M, and CPT-04D. In March 1998, the highest dissolved BTEX concentration detected was in monitoring point CPT-03S at a concentration of 22,400 µg/L (Table 4). Monitoring point CPT-03S is located approximately 100 feet downgradient from the UST area at Site ST-29 (Figure 3). The dissolved BTEX concentration detected at well CPT-03S in March 1998 represents an increase from March 1994 and March 1995, when concentrations of 7,300 µg/L and 14,100 µg/L, respectively, were detected.

Dissolved BTEX concentrations near the source area are increasing, indicating that residual fuel hydrocarbons still exist in source area soils. Residual soil contamination may persist within the capillary fringe or saturated smear zone, which is unaffected by bioventing. The increase in average groundwater elevation of 0.4 foot from March 1994 to January 1996 (Section 2.1) would increase the volume of saturated soil in the source area, decrease the volume of unsaturated soil subject to the effects of bioventing, and result in increased dissolution of BTEX into the groundwater.

In the downgradient direction there has been a notable increase in total BTEX at monitoring point CPT-04D. BTEX at CPT-04D increased from low levels (less than 5 µ g/L) in 1994, 1995, and 1996 to 1,180 µg/L in March 1998. Although the overall extent of the BTEX plume has not increased since 1994, concentrations of BTEX within the plume have increased. This increase in concentrations could potentially result in future expansion of the plume.

FIGURE 5
DISSOLVED BTEX IN SELECTED WELLS ALONG THE PLUME AXIS
MARCH 1994 TO MARCH 1998
INTRINSIC REMEDIATION TREATABILITY STUDY ADDENDUM
SITE ST-29
PATRICK AFB, FLORIDA




s://bioplume/patrick/st-29/updatefiles/Fig5.xls

7/14/1999

Two groundwater model simulations were completed using the Bioplume II modeling code during the TS (Parsons ES, 1995). A conservative model that did not consider reductions in the source concentrations (worst-case scenario), predicted that the BTEX plume would stabilize approximately 30 years after 1994 (2024) with the leading edge approximately 1,400 feet beyond the source area (or approximately 700 to 800 feet beyond the toe of the 1994 BTEX plume).

The second model simulation assumed that BTEX loading rates were significantly reduced by bioventing over a three year period. This model was used to simulate the expected reduction due to operation of the full-scale bioventing system installed at the site in June 1995. Model results, as described in the TS report, indicate that after 3 years of bioventing, the plume front would only migrate about 100 feet downgradient from the 1994 plume extent. After 5 years of bioventing, the model predicts that the plume front would retreat to the 1994 plume extent. Model results indicate that the BTEX plume would be completely degraded seven years after bioventing begins.

Actual monitoring results indicate that the models underestimated the maximum concentration of dissolved BTEX that would be present in the plume over time, but that the downgradient extent of the plume is conservatively overestimated by both models (especially the no-source-reduction model). While the extent of the BTEX plume has not increased, the bioventing system does not appear to have a significant impact on total dissolved BTEX concentrations. While bioventing is effective in reducing soil BTEX concentrations in the vadose zone, the lack of an impact on dissolved BTEX concentrations suggests that a residual source of BTEX (i.e., a smear zone) persists, most likely within the capillary fringe or saturated zone.

## 2.3 MTBE

All groundwater samples collected in January 1996 and March 1998 were analyzed for MTBE (Figure 4). MTBE is a fuel oxygenate used to enhance fuel octane rating and to reduce emissions. The maximum MTBE concentration detected was at monitoring point CPT-02S (514 μg/L) in January 1996. Monitoring point CPT-02S was not sampled in 1998. With the exception of CPT-09S, MTBE concentrations decreased at monitoring points sampled in both 1996 and 1998. For example, MTBE concentrations at sampling location CPT-09D decreased from 353 μg/L in January 1996 to 31.1 μg/L in March 1998. Likewise, MTBE concentrations at CPT-12D decreased from 348 μg/L in January 1996 to 68.4 μg/L in 1998. The decrease in MTBE concentrations may indicate that MTBE is naturally attenuating at the site. Conversely, because MTBE is often recalcitrant, the observed concentration decreases may indicate that the contaminant source is being preferentially depleted of MTBE due to its high solubility.

## 2.4 Chlorinated Volatile Organic Compounds

All groundwater samples collected in January 1996 were analyzed for CVOCs. In no instances were any CVOCs detected in the thirteen samples collected during this sampling event (Appendix A). Samples collected during the March 1998 sampling event were not analyzed for CVOCs.

## 2.5 Inorganic Chemistry and Geochemical Indicators of Biodegradation

As discussed in the TS, microorganisms obtain energy for cell production and maintenance by facilitating thermodynamically advantageous oxidation/reduction reactions involving the transfer of electrons from electron donors to available electron acceptors. This results in the oxidation of the electron donor and the reduction of the electron acceptor. Electron donors at Site ST-29 are natural organic carbon and fuel hydrocarbon compounds. Fuel hydrocarbons are completely degraded or detoxified if they are utilized as the primary electron donor for microbial metabolism (Bouwer, 1992). Electron acceptors are elements or compounds that occur in relatively oxidized states and include oxygen, nitrate, manganese, ferrous iron, sulfate, and carbon dioxide. Microorganisms preferentially utilize electron acceptors while metabolizing fuel hydrocarbons (Bouwer, 1992). DO is utilized first as the prime electron acceptor. After the DO is consumed, anaerobic microorganisms use electron acceptors in the following order of preference: nitrate, manganese, ferric iron, sulfate, and finally carbon dioxide. Anaerobic destruction of the BTEX compounds is associated with the accumulation of fatty acids, production of methane, solubilization of iron, and reduction of nitrate and sulfate (Cozzarelli *et al.*, 1990; Wilson *et al.*, 1990).

### Oxidation-Reduction Potential

ORP, a measure of the relative tendency of a solution to accept or transfer electrons, was measured at 13 monitoring locations during the January 1996 sampling event and at 12 locations during the March 1998 sampling event. The dominant electron acceptor being reduced by microbes during BTEX oxidation can be correlated to the ORP of the groundwater. Site ORPs from 1994 to 1998 are summarized on Table 5. In January 1996, the ORP measured at Site ST-29 ranged from –154 millivolts (mV) at CPT-03M, to –45 mV at CPT-16DD. In general, the ORPs measured in March 1998 were lower than in previous sampling periods, ranging from -313 mV (CPT-03S) to -110 mV (CPT-18D). ORP data suggest that dissolved BTEX at the site may be subjected to a variety of biodegradation processes, including aerobic respiration, denitrification, iron reduction, and sulfate reduction. However, many authors have noted that field ORP data alone cannot be used to reliably predict the electron acceptors that may be operating at a site, because the platinum electrode probes are not sensitive to some ORP couples (e.g., sulfate/sulfide) (Stumm and Morgan, 1981; Godsey, 1994; Lovley *et al.*, 1994).

The areal distributions of ORP at the site in 1994, 1995, 1996, and 1998 are presented on Figure 6. Comparison of Figure 3 with Figure 6 illustrates that areas with elevated total BTEX concentrations have lower ORP, with the lowest ORP values occurring in the core of the plume. The correlation between decreased ORP and elevated BTEX concentrations is a strong indication that biodegradation of the BTEX compounds is occurring.

Temporal changes in ORP at several monitoring locations from March 1994 to March 1998 are plotted on Figure 7. The monitoring locations plotted on Figure 7 are located along the approximate longitudinal centerline of the dissolved BTEX plume. In general, ORP decreased from March 1994 to March 1995, increased from March 1995 to January 1996, and then decreased again from January 1996 to March 1998. Comparison of Figure 5 and Figure 7 show that changes in ORP measured at monitoring locations are generally

**TABLE 5**
**GROUNDWATER GEOCHEMICAL DATA**
**INTRINSIC REMEDIATION TREATABILITY STUDY ADDENDUM**
**SITE ST-29**
**PATRICK AFB, FLORIDA**

| Sample Location | Sample Date | ORP[a] (mV)[d] | Dissolved Oxygen (mg/L)[e] | Nitrate+ Nitrite (mg/L) | Ammonia (mg/L) | Manganese (mg/L) | Ferrous Iron (mg/L) | Sulfate (mg/L) | Hydrogen Sulfide (mg/L) | Carbon Dioxide (mg/L) | Methane (mg/L) | Ethylene (mg/L) | Ethane (mg/L) | TOC[b] (mg/L) | Alkalinity (as $CaCO_3$[c]) (mg/L) | Chlorides (mg/L) | Temperature (°C)[f] | pH | Conductivity (µs/cm)[g] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CPT-01 | Mar-94 | NA[h] | 0.4 | 0.13 | NA | NA | NA | 4.37 | NA | NA | 4.99 | NA | NA | 14.0 | NA | 44.4 | 24.7 | NA | NA |
| CPT-02S | Mar-94 | -156 | 0.2 | 0.12 | NA | NA | 1.6 | <0.5[i] | 0.2 | NA | 15.0 | NA | NA | 16.9 | 498 | 42.6 | 24.7 | 6.7 | 1,060 |
| | Mar-95 | -231 | 0.1 | 0.06 | 3.83 | <0.1 | 1.1 | 1.13 | NA | 420 | 12.8 | NA | NA | 14.9 | 404 | 62.7 | NA | 6.54 | 998 |
| | Mar-95 (Dup)[j] | -225 | 0.1 | 0.07 | 3.79 | <0.1 | 1.1 | 1.08 | NA | 416 | 14.2 | NA | NA | 16.3 | 407 | 67.7 | NA | 6.53 | 995 |
| | Jan-96 | -60 | 0.2 | <0.05 | NA | NA | 1.2 | <0.5 | 0.5 | NA | NA | NA | NA | 14.9 | 480 | NA | 24.7 | 7.5 | 870 |
| CPT-02D | Mar-94 | -190 | 0.6 | 0.13 | NA | NA | 0.4 | <0.5 | 0.4 | NA | 5.95 | NA | NA | 6.8 | 330 | 45.7 | 24.7 | 7.1 | 771 |
| CPT-03S | Mar-94 | -208 | 0.1 | 14.8 | NA | NA | 1.2 | 118 | 0.1 | NA | 14.0 | NA | NA | 63.1 | 520 | 132 | 26.4 | 6.7 | 1,730 |
| | Mar-95 | -357 | <0.1 | <0.05 | 18.2 | <0.1 | 0.1 | 14 | NA | 780 | 15.5 | NA | NA | 182 | 920 | 129 | NA | 6.72 | 2,010 |
| | Jan-96 | -152 | <0.1 | <0.05 | NA | NA | 0.6 | 10.0 | 30 | NA | NA | NA | NA | 119 | 500 | NA | NA | NA | 1,270 |
| | Mar-98 | -313 | <0.1 | 0.25 | 1.29 | 0.1 | 0.1 | 12.6 | 35 | 130 | 22.1 | ND | 0.019 | 30.7 | 240 | 64.5 | 23.3 | 7.5 | NA |
| CPT-03M | Mar-94 | -50 | 0.2 | 0.11 | NA | NA | 0.3 | 2.52 | 0 | NA | 3.16 | NA | NA | 10.9 | 398 | 40.7 | 26.4 | 7.1 | 898 |
| | Mar-95 | -343 | <0.1 | 0.06 | 6.13 | <0.1 | <0.05 | 19.6 | NA | 338 | 12.4 | NA | NA | 35.8 | 447 | 42.6 | NA | 6.77 | 1,020 |
| | Jan-96 | -145 | 0.1 | <0.05 | NA | NA | < 0.1 | 15.7 | 6 | NA | NA | NA | NA | 10.4 | 290 | NA | 25.1 | 6.9 | 662 |
| | Mar-98 | -276 | <0.1 | <0.1 | 3.91 | <0.1 | 0.1 | 46.4 | 8 | 105 | 16.8 | ND | 0.010 | 24.2 | 320 | 40.9 | 24.4 | 7.0 | NA |
| CPT-03D | Mar-94 | -255 | NA | 0.12 | NA | NA | 0.4 | <0.5 | 1 | NA | 1.63 | NA | NA | 5.4 | 315 | 41.6 | NA | 7.3 | 721 |
| | Mar-95 | -348 | 0.1 | 0.08 | 1.18 | <0.1 | <0.05 | 15.7 | 5 | 144 | 2.57 | NA | NA | 13.8 | 341 | 46.5 | NA | 7.02 | 787 |
| | Mar-95 (Dup) | -347 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 7.04 | 786 |
| | Jan-96 | -154 | 0.1 | <0.05 | NA | NA | < 0.1 | 16.5 | 6 | NA | NA | NA | NA | 9.1 | 280 | NA | 26.4 | 7.2 | 599 |
| | Mar-98 | -306 | 0.1 | <0.1 | 1.36 | 0.1 | 0.1 | 5.53 | 5 | 75 | 3.42 | ND | <0.002 | 11.9 | 260 | 33.9 | 25.5 | 7.2 | NA |
| | Mar-98 (Dup) | NA | NA | NA | NA | NA | NA | NA | NA | NA | 3.40 | ND | ND | NA | NA | NA | NA | NA | NA |
| CPT-04S | Mar-94 | -286 | 0.3 | 0.19 | NA | NA | 0.6 | <0.5 | 0.5 | NA | 7.66 | NA | NA | 6.6 | 215 | 12.5 | 26.9 | 6.9 | 469 |
| | Mar-95 | -289 | 0.1 | 0.07 | 3.6 | <0.1 | 0.1 | 1.17 | 1 | 138 | 11.6 | NA | NA | 7.5 | 263 | 15.8 | NA | 6.85 | 543 |
| | Mar-95 (Dup) | NA | NA | NA | NA | NA | NA | NA | NA | NA | 10.6 | NA | NA | 7.5 | NA | NA | NA | NA | NA |
| | Jan-96 | -124 | 0.3 | <0.05 | NA | NA | < 0.1 | 4.26 | 2 | NA | NA | NA | NA | 4.2 | 170 | NA | 24.8 | 7.1 | 522 |
| | Mar-98 | -288 | 0.2 | <0.1 | 2 | <0.1 | <0.1 | 6.21 | 3 | 70 | 11.1 | ND | ND | 5.23 | 220 | 15.4 | 25.1 | 7.2 | 464 |
| CPT-04D | Mar-94 | -266 | 0.2 | 0.09 | NA | NA | 0.6 | 1.47 | 0.2 | NA | 3.76 | NA | NA | 5.6 | 212 | 12.4 | 26.1 | 7.2 | 457 |
| | Mar-95 | -325 | <0.1 | 0.07 | 2.53 | <0.1 | 0.1 | 2.98 | 5 | 90 | 5.10 | NA | NA | 7.8 | 259 | 18.4 | NA | 7.04 | 540 |
| | Jan-96 | -114 | 0.1 | <0.05 | NA | NA | 0.2 | 21.5 | 12 | NA | NA | NA | NA | 4.9 | 260 | NA | 25.2 | 6.9 | 654 |
| | Mar-95 (Dup) | NA | NA | NA | NA | NA | NA | 21.9 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| | Mar-98 | -286 | 0.1 | <0.1 | 2.11 | 0.1 | 0.2 | 12.7 | 5 | 70 | 8.50 | ND | ND | 6.21 | 200 | 17 | 25.4 | 8.0 | 497 |
| CPT-05S | Mar-94 | -160 | 1.1 | 0.17 | NA | NA | 0.1 | 6.86 | 0.1 | NA | 4.86 | NA | NA | 12 | 215 | 23.6 | 26.4 | 7.3 | 488 |
| CPT-06S | Mar-94 | -278 | 0.2 | 0.13 | NA | NA | 0.3 | 7.03 | 1.5 | NA | 6.60 | NA | NA | 3.8 | 148 | 47.8 | 25.1 | 7.6 | 437 |
| CPT-07S | Mar-94 | -250 | 0.2 | 0.12 | NA | NA | 1 | 2.52 | 1.2 | NA | 6.34 | NA | NA | 3.4 | 254 | 30.2 | 25.3 | 7.2 | 577 |
| CPT-08S | Mar-94 | -60 | 0.2 | 0.1 | NA | NA | 1.9 | 8.51 | 0 | NA | 1.74 | NA | NA | 10.1 | 420 | 44.7 | 25.0 | 7.1 | 974 |
| CPT-04D | Mar-94 | -266 | 0.2 | 0.09 | NA | NA | 0.6 | 1.47 | 0.2 | NA | 3.76 | NA | NA | 5.6 | 212 | 12.4 | 26.1 | 7.2 | 457 |
| | Mar-95 | -325 | <0.1 | 0.07 | 2.53 | <0.1 | 0.1 | 2.98 | 5 | 90 | 5.10 | NA | NA | 7.8 | 259 | 18.4 | NA | 7.04 | 540 |
| | Jan-96 | -114 | 0.1 | <0.05 | NA | NA | 0.2 | 21.5 | 12 | NA | NA | NA | NA | 4.9 | 260 | NA | 25.2 | 6.9 | 654 |
| | Jan-96 (Dup) | NA | NA | NA | NA | NA | NA | 21.9 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| | Mar-98 | -286 | 0.1 | <0.1 | 2.11 | 0.1 | 0.2 | 12.7 | 5 | 70 | 8.50 | NA | NA | 6.21 | 200 | 17 | 25.4 | 8.0 | 497 |
| CPT-05S | Mar-94 | -160 | 1.1 | 0.17 | NA | NA | 0.1 | 6.86 | 0.1 | NA | 4.86 | NA | NA | 12 | 215 | 23.6 | 26.4 | 7.3 | 488 |
| CPT-06S | Mar-94 | -278 | 0.2 | 0.13 | NA | NA | 0.3 | 7.03 | 1.5 | NA | 6.60 | NA | NA | 3.8 | 148 | 47.8 | 25.1 | 7.6 | 437 |

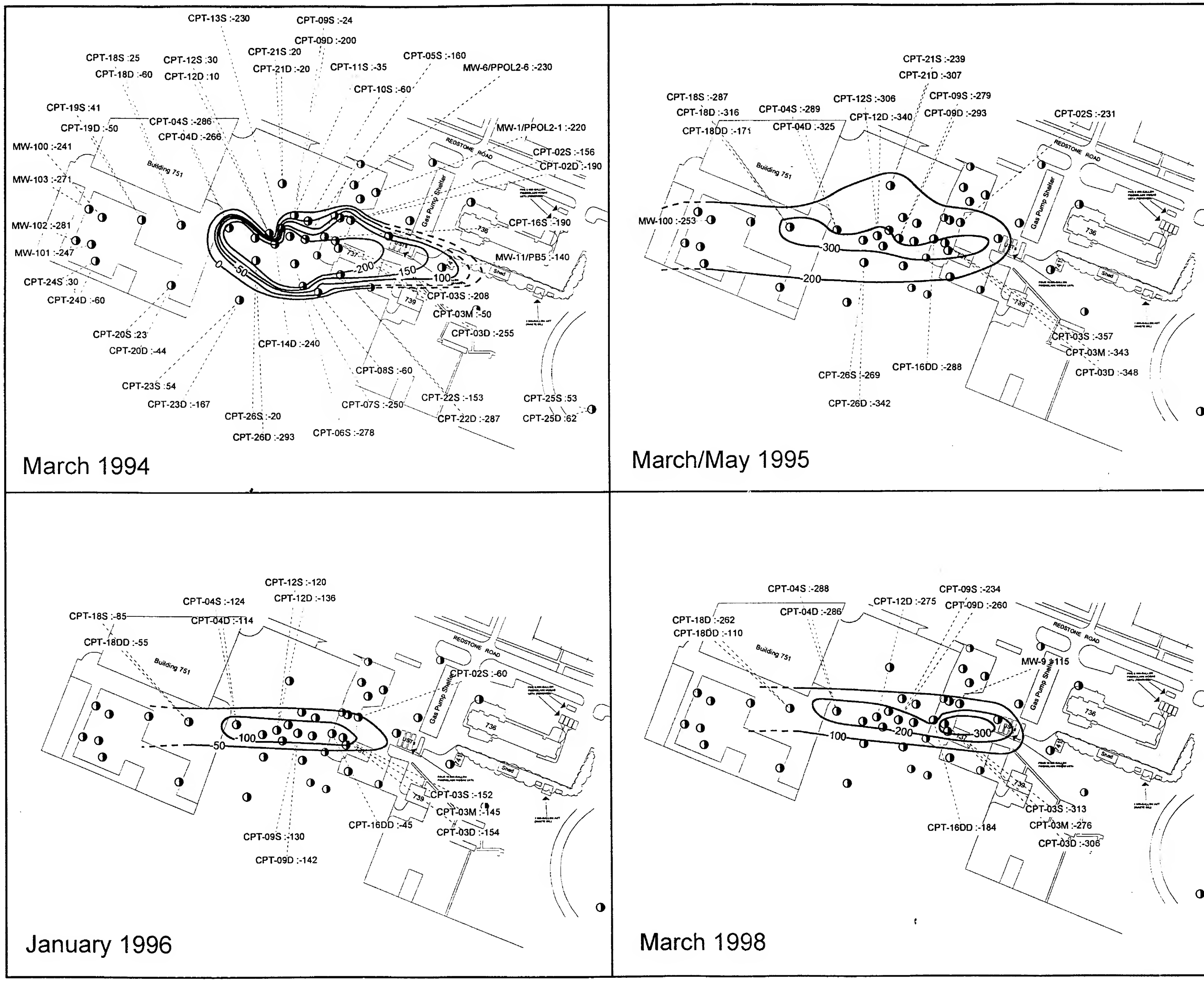
**TABLE 5 (Continued)**
**GROUNDWATER GEOCHEMICAL DATA**
**INTRINSIC REMEDIATION TREATABILITY STUDY ADDENDUM**
**SITE ST-29**
**PATRICK AFB, FLORIDA**

| Sample Location | Sample Date | ORP[a] (mV)[d] | Dissolved Oxygen (mg/L)[e] | Nitrate+ Nitrite (mg/L) | Ammonia (mg/L) | Manganese (mg/L) | Ferrous Iron (mg/L) | Sulfate (mg/L) | Hydrogen Sulfide (mg/L) | Carbon Dioxide (mg/L) | Methane (mg/L) | Ethylene (mg/L) | Ethane (mg/L) | TOC[b] (mg/L) | Alkalinity (as $CaCO_3$[c]) (mg/L) | Chlorides (mg/L) | Temperature (°C)[f] | pH | Conductivity (µs/cm)[g] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CPT-07S | Mar-94 | -250 | 0.2 | 0.12 | NA | NA | 1 | 2.52 | 1.2 | NA | 6.34 | NA | NA | 3.4 | 254 | 30.2 | 25.3 | 7.2 | 577 |
| CPT-08S | Mar-94 | -60 | 0.2 | 0.1 | NA | NA | 1.9 | 8.51 | 0 | NA | 1.74 | NA | NA | 10.1 | 420 | 44.7 | 25.0 | 7.1 | 974 |
| CPT-09S | Mar-94 | -24 | 0.2 | 0.1 | NA | NA | 0.2 | 6.64 | 0 | NA | 3.80 | NA | NA | 10.2 | 340 | 14.3 | 27.3 | 7.3 | 530 |
| | Mar-95 | -279 | 0.1 | 0.07 | 1.71 | <0.1 | 0.1 | 1.52 | 1 | 80 | 5.82 | NA | NA | 3 | 180 | 9.46 | NA | 7.38 | 391 |
| | Jan-96 | -130 | 0.2 | <0.05 | NA | NA | 0.1 | 1.45 | 16 | NA | NA | NA | NA | 1.5 | 170 | NA | 24.0 | 6.9 | 386 |
| | Mar-98 | -234 | <0.1 | <0.1 | 1.09 | <0.1 | <0.1 | 7.88 | 2 | 25 | 4.50 | ND | ND | 3.12 | 130 | 7.64 | 24.2 | 7.2 | 312 |
| CPT-9M | Jan-96 | -142 | 0.2 | <0.05 | NA | NA | 0.1 | 1.71 | 18 | NA | NA | NA | NA | 26.7 | 350 | NA | 25.3 | 7.2 | 706 |
| CPT-09D | Mar-94 | -200 | 0.3 | 0.11 | NA | NA | 0.2 | 15.3 | 0.6 | NA | 4.24 | NA | NA | 12 | 422 | 34.7 | 27.8 | 7.1 | 938 |
| | Mar-95 | -293 | 0.1 | 0.06 | 3.85 | <0.1 | <0.05 | 2.23 | 5 | 284 | 9.84 | NA | NA | 21.8 | 469 | 51.1 | NA | 6.78 | 995 |
| | Mar-98 | -260 | <0.1 | <0.1 | 2.32 | <0.1 | <0.1 | 3.69 | 2 | 70 | 10.1 | ND | 0.008 | 16.9 | 320 | 38.7 | 25.2 | 8.2 | 775 |
| | Mar-98 (Dup) | NA | NA | NA | NA | NA | NA | NA | NA | NA | 10.4 | ND | 0.008 | NA | NA | NA | NA | NA | NA |
| CPT-10S | Mar-94 | -60 | 0.1 | 0.13 | NA | NA | 0.2 | 9.5 | 0 | NA | 3.49 | NA | NA | 21.3 | 192 | 26.6 | 26.0 | 7.3 | 460 |
| CPT-11S | Mar-94 | -35 | 0.1 | 0.15 | NA | NA | 0.4 | 15.9 | 0 | NA | 4.24 | NA | NA | NA | 210 | 12.7 | 25.9 | 7.2 | 508 |
| CPT-12S | Mar-94 | 30 | 0.9 | 0.1 | NA | NA | 0.1 | 8.38 | 0 | NA | 5.37 | NA | NA | 10.5 | 266 | 15.2 | 27.3 | 7 | 564 |
| | Mar-95 | -306 | <0.1 | 0.07 | 4.04 | <0.1 | 0.3 | 0.98 | 1 | 142 | 12.3 | NA | NA | 6.1 | 220 | 14.4 | NA | 7.05 | 498 |
| | Jan-96 | -120 | 0.1 | <0.05 | NA | NA | 0.2 | <0.5 | 0.2 | NA | NA | NA | NA | 1.7 | 180 | NA | 24.4 | 7 | 474 |
| CPT-12D | Mar-94 | 10 | 0.4 | 0.12 | NA | NA | 0.1 | 3.86 | 0.1 | NA | 0.983 | NA | NA | 8.1 | 329 | 28.1 | 27.1 | 7.2 | 715 |
| | Mar-95 | -340 | <0.1 | 0.05 | 2.37 | <0.1 | <0.05 | 49.7 | 5 | 202 | 0.882 | NA | NA | 10.9 | 359 | 56.9 | NA | 6.93 | 946 |
| | Jan-96 | -136 | 0.1 | <0.05 | NA | NA | 0.1 | 2.85 | 14 | NA | NA | NA | NA | 14.8 | 320 | NA | 26.0 | 7.1 | 940 |
| | Mar-98 | -275 | <0.1 | <0.1 | 2.13 | <0.1 | <0.1 | 7.7 | 7 | 90 | 7.64 | ND | 0.006 | 12.4 | 360 | 47.2 | 26.0 | 7.8 | NA |
| CPT-13S | Mar-94 | -230 | 0.1 | 0.12 | NA | NA | 0.3 | 6.94 | 0.6 | NA | 2.04 | NA | NA | 7.2 | 362 | 35.5 | 25.7 | 7.3 | 801 |
| CPT-14D | Mar-94 | -240 | 0.3 | 0.11 | NA | NA | 0.3 | 3.68 | 0.6 | NA | 8.79 | NA | NA | 12.8 | 460 | 34.6 | 25.5 | 7 | 906 |
| CPT-16S | Mar-94 | -190 | 0.1 | 0.13 | NA | NA | 0.4 | 8.23 | 0.1 | NA | 0.781 | NA | NA | 9.4 | 231 | 37.9 | 25.5 | 7 | 776 |
| CPT-16DD | Mar-94 | NA | 2.7 | NA | NA | NA | NA | NA | 0.3 | NA | NA | NA | NA | NA | NA | NA | 26.7 | NA | NA |
| | Mar-95 | -288 | 0.1 | <0.05 | 16.9 | <0.1 | <0.05 | 1200 | NA | 238 | 0.074 | NA | NA | 4.6 | 307 | 9,830 | NA | 7.13 | 26,900 |
| | Jan-96 | -45 | 0.2 | <0.05 | NA | NA | < 0.1 | 278 | 0.3 | NA | NA | NA | NA | 4.2 | 380 | NA | 26.9 | 7.2 | 8,700 |
| | Mar-98 | -184 | <0.1 | <0.1 | 17 | 0.1 | 0.2 | 1020 | <0.1 | 110 | 0.023 | ND | ND | 6.99 | 360 | 10,000 | 25.9 | 7.8 | NA |
| CPT-16S | Mar-94 | -190 | 0.1 | 0.13 | NA | NA | 0.4 | 8.23 | 0.1 | NA | 0.781 | NA | NA | 9.4 | 231 | 37.9 | 25.5 | 7 | 776 |
| CPT-16DD | Mar-94 | NA | 2.7 | NA | NA | NA | NA | NA | 0.3 | NA | NA | NA | NA | NA | NA | NA | 26.7 | NA | NA |
| | Mar-95 | -288 | 0.1 | <0.05 | 16.9 | <0.1 | <0.05 | 1200 | NA | 238 | 0.074 | NA | NA | 4.6 | 307 | 9,830 | NA | 7.13 | 26,900 |
| | Jan-96 | -45 | 0.2 | <0.05 | NA | NA | < 0.1 | 278 | 0.3 | NA | NA | NA | NA | 4.2 | 380 | NA | 26.9 | 7.2 | 8,700 |
| | Mar-98 | -184 | 0.0 | <0.1 | 17 | 0.1 | 0.2 | 1020 | <0.1 | 110 | 0.023 | NA | NA | 6.99 | 360 | 10,000 | 25.9 | 7.8 | NA |
| CPT-18S | Mar-94 | 25 | 2 | 0.12 | NA | NA | 0.5 | 86 | 0 | NA | NA | NA | NA | 7.8 | 286 | 36.6 | 26.6 | 6.9 | 834 |
| | Mar-95 | -287 | 0.1 | 0.07 | 0.35 | <0.1 | 0.2 | 59.6 | 0.7 | 110 | 3.38 | NA | NA | 4 | 276 | 18.3 | NA | 6.85 | 675 |
| | Jan-96 | -85 | 0.3 | <0.05 | NA | NA | 0.3 | 43.3 | 0.6 | NA | NA | NA | NA | 3.3 | 220 | NA | 24.7 | 6.9 | 551 |
| | Mar-98 | NA | NA | <0.1 | 0.47 | <0.1 | <0.1 | 10.8 | 0.4 | 70 | 4.09 | ND | ND | 6.82 | 240 | 10.3 | NA | 7.8 | NA |
| CPT-18D | Mar-94 | -60 | 0.3 | 0.11 | NA | NA | 0.3 | 1.85 | 0.2 | NA | 4.56 | NA | NA | 5.6 | 294 | 15 | 26.1 | 7.1 | 620 |
| | Mar-95 | -316 | 0.1 | 0.07 | 1.52 | <0.1 | 0.1 | 1.08 | 2 | 98 | 6.12 | NA | NA | 5.8 | 289 | 29.6 | NA | 6.87 | 652 |
| | Mar-98 | -262 | <0.1 | <0.1 | 1.4 | <0.1 | 0.1 | 2.05 | 2.5 | 50 | 7.56 | ND | ND | 6.47 | 220 | 20.4 | 26.1 | 7.5 | 740 |

## TABLE 5 (Concluded)
## GROUNDWATER GEOCHEMICAL DATA
### INTRINSIC REMEDIATION TREATABILITY STUDY ADDENDUM
### SITE ST-29
### PATRICK AFB, FLORIDA

| Sample Location | Sample Date | ORP[a] (mV)[d] | Dissolved Oxygen (mg/L)[e] | Nitrate+ Nitrite (mg/L) | Ammonia (mg/L) | Manganese (mg/L) | Ferrous Iron (mg/L) | Sulfate (mg/L) | Hydrogen Sulfide (mg/L) | Carbon Dioxide (mg/L) | Methane (mg/L) | Ethylene (mg/L) | Ethane (mg/L) | TOC[b] (mg/L) | Alkalinity (as $CaCO_3$[c]) (mg/L) | Chlorides (mg/L) | Temperature (°C)[f] | pH | Conductivity (µs/cm)[g] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CPT-18DD | Mar-94 | NA | 2.3 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 27.3 | NA | NA |
| | Mar-95 | -171 | 0.2 | <0.05 | 16.2 | <0.1 | 0.1 | 967 | <0.1 | 276 | 0.068 | NA | NA | 4.2 | 335 | 9,080 | NA | 7.19 | 26,500 |
| | Jan-96 | -55 | 0.3 | <0.05 | NA | NA | 0.1 | 245 | 0.1 | NA | NA | NA | NA | 5.3 | 270 | NA | 26.7 | 7.5 | 11,000 |
| | Mar-98 | -110 | <0.1 | <0.1 | 16.8 | <0.1 | 0.1 | 1040 | 0.1 | 100 | 0.030 | NA | NA | 6.74 | 340 | 8,900 | 27.4 | 7.8 | 260 |
| | Mar-98 (Dup) | NA | NA | NA | NA | NA | NA | NA | NA | NA | 0.029 | ND | ND | NA | NA | NA | NA | NA | NA |
| CPT-19S | Mar-94 | 41 | NA | 0.11 | NA | NA | 0.1 | 8.85 | 0 | NA | 0.924 | NA | NA | 10.3 | 335 | 37.4 | NA | 7 | 800 |
| CPT-19D | Mar-94 | -50 | 0.2 | 0.1 | NA | NA | 0.2 | 1.51 | 0.2 | NA | 2.14 | NA | NA | 7.3 | 328 | 33.7 | 26.6 | 7.1 | 744 |
| CPT-20S | Mar-94 | 23 | 1.5 | 0.1 | NA | NA | 0.3 | 25.5 | 0 | NA | 1.28 | NA | NA | 3.6 | 148 | 9.83 | 25.0 | 7 | 368 |
| CPT-20D | Mar-94 | -44 | 0.3 | 0.07 | NA | NA | 0.2 | <0.5 | 0.1 | NA | 1.11 | NA | NA | 8.6 | 380 | 52 | 25.7 | 7.1 | 842 |
| CPT-21S | Mar-94 | 20 | 3.2 | 0.29 | NA | NA | 0.2 | 25.5 | 0 | NA | 2.41 | NA | NA | 7.6 | 245 | 26.6 | 26.0 | 7.1 | 610 |
| | Mar-95 | -239 | 0.1 | 0.08 | 2.94 | NA | 0.6 | 0.52 | 0.7 | 190 | 9.86 | NA | NA | 4.9 | 177 | 12.3 | NA | 6.92 | 381 |
| CPT-21D | Mar-94 | -20 | 0.2 | 0.14 | NA | NA | 0.2 | 13.3 | 0.1 | NA | 0.46 | NA | NA | 6.1 | 304 | 29.8 | 26.4 | 7.2 | 716 |
| | Mar-95 | -307 | <0.1 | 0.07 | 0.47 | NA | 0.1 | 38.8 | 5 | 96 | 0.749 | NA | NA | NA | 287 | 28.2 | NA | 7.18 | 674 |
| CPT-22S | Mar-94 | -153 | 0.3 | 0.07 | NA | NA | 1.2 | 128 | 0 | NA | 3.22 | NA | NA | 10 | 450 | 66.6 | 25.5 | 6.8 | 1,270 |
| CPT-22D | Mar-94 | -287 | 0.1 | 0.12 | NA | NA | 0.2 | NA | 5 | NA | 0.866 | NA | NA | 11.4 | 415 | NA | 25.4 | 6.9 | 936 |
| CPT-23S | Mar-94 | 54 | 3.5 | 0.12 | NA | NA | 0.2 | <0.5 | 0 | NA | 1.99 | NA | NA | 6.4 | 346 | 23.4 | 26.5 | 6.9 | 757 |
| CPT-23D | Mar-94 | -167 | 0.4 | 0.1 | NA | NA | 0.2 | 1.49 | 0.2 | NA | 2.28 | NA | NA | 8.2 | 332 | 36.1 | 26.7 | 7.1 | 779 |
| CPT-24S | Mar-94 | 30 | 1.7 | 0.12 | NA | NA | 0.1 | <0.5 | 0 | NA | 2.20 | NA | NA | 5.6 | 190 | 6.63 | 25.7 | 7 | 358 |
| CPT-24D | Mar-94 | -60 | 0.3 | 0.1 | NA | NA | 0.1 | 3.61 | 0.1 | NA | 0.686 | NA | NA | 2.8 | 192 | 5.46 | 26.0 | 7.5 | 376 |
| CPT-25S | Mar-94 | 53 | 3.7 | 0.12 | NA | NA | <0.05 | 51.9 | 0 | NA | 0.147 | NA | NA | 15.7 | 157 | 28 | 25.0 | 7.3 | 664 |
| CPT-25D | Mar-94 | 62 | NA | 0.12 | NA | NA | <0.05 | 6.16 | 0 | NA | 1.56 | NA | NA | 15.7 | 371 | 54.7 | NA | 7.1 | 892 |
| CPT-26S | Mar-94 | -20 | 2.2 | 0.12 | NA | NA | 0.3 | 1.22 | 0 | NA | 3.57 | NA | NA | 5 | 264 | 15.1 | 26.0 | 7.6 | 558 |
| | Mar-95 | -269 | 0.1 | 0.07 | 1.01 | <0.1 | 0.3 | 0.94 | 0.7 | 154 | 9.01 | NA | NA | 3.4 | 202 | 13.2 | NA | 6.87 | 440 |
| CPT-26D | Mar-94 | -293 | 0.2 | 0.11 | NA | NA | 0.4 | 19.8 | 3 | NA | 2.96 | NA | NA | 8.3 | 311 | 44.9 | 26.2 | 7 | 751 |
| | Mar-95 | -342 | 0.1 | 0.06 | 2.61 | <0.1 | <0.05 | 3.31 | 5 | 192 | 3.76 | NA | NA | 9.5 | 357 | 51.2 | NA | 6.88 | 837 |
| MW-9 | Mar-98 | -115 | 0.3 | <0.1 | <0.1 | <0.1 | 0.1 | 4 | <0.1 | 50 | 0.048 | ND | ND | 2.9 | 130 | 2.68 | 21.9 | 7.6 | NA |
| MW-100 | Mar-94 | -241 | 0.5 | 0.12 | NA | NA | 0.1 | 16.3 | 0.2 | NA | 2.82 | NA | NA | 18.6 | 331 | 24.9 | 25.9 | 7.2 | 607 |
| | Mar-95 | -253 | <0.1 | 0.07 | 0.23 | <0.1 | 0.3 | 10 | 0.3 | 132 | NA | NA | NA | 3.3 | 205 | 15.2 | NA | 7.32 | 429 |
| MW-101 | Mar-94 | -247 | 0.3 | 0.13 | NA | NA | 0.1 | 5.75 | 0.8 | NA | 2.31 | NA | NA | 9 | 287 | 21.6 | 26.5 | 7.2 | 533 |
| MW-102 | Mar-94 | -281 | 0.2 | 0.12 | NA | NA | 0.1 | 3.51 | 0.5 | NA | 3.26 | NA | NA | 7.6 | 250 | 17.9 | 25.8 | 7.2 | 523 |
| MW-103 | Mar-94 | -271 | 0.1 | 0.11 | NA | NA | 0.1 | 4.69 | 1 | NA | 5.29 | NA | NA | 2.6 | 209 | 12.5 | 25.4 | 7.4 | 445 |
| PB5/MW-11 | Mar-94 | -140 | 0.2 | 0.1 | NA | NA | <0.05 | 4.45 | NA | NA | 4.41 | NA | NA | NA | 291 | 51.4 | 24.9 | 7.1 | 743 |
| PPOL2-1/M | Mar-94 | -220 | 0.1 | <0.05 | NA | NA | 0.6 | 3.2 | 0.7 | NA | 5.33 | NA | NA | NA | 305 | 44 | 26.3 | 7.1 | 747 |
| PPOL2-6/M | Mar-94 | -230 | 0.2 | <0.05 | NA | NA | NA | 1,150 | 0.8 | NA | 0.034 | NA | NA | NA | 334 | 10,200 | 27.2 | 7 | 30,100 |

[a] ORP = Oxidation Reduction Potential.
[b] TOC = Total Organic Carbon.
[c] $CaCO_3$ = Calcium Carbonate.
[d] mV = millivolts .
[e] mg/L = milligrams per liter .
[f] °C = Degrees Celsius.
[g] µs/cm = microsiemens per centimeter.
[h] NA = not analyzed.
[i] "<" = analyte detected at a concentration less than quantitation limit.
[j] Dup = Duplicate sample.




## LEGEND

| | |
|---|---|
| MW-100 : -253 | Monitoring Location ID and Oxidation-Reduction Potential (millivolts) |
| 100 | Oxidation-Reduction Potential Isopleth (millivolts) |
| UST | Underground Storage Tank |
| AST | Aboveground Storage Tank |
| MOGAS | Motor Vehicle Gasoline |

NOTE: Where values from different depths differ, the value from the depth corresponding with the highest total BTEX concentration was used to generate contours.

0 100 200
Feet

N

FIGURE 6

OXIDATION-REDUCTION POTENTIAL IN GROUNDWATER

Site ST-29
Intrinsic Remediation Treatability Study Addendum
Patrick Air Force Base, Florida

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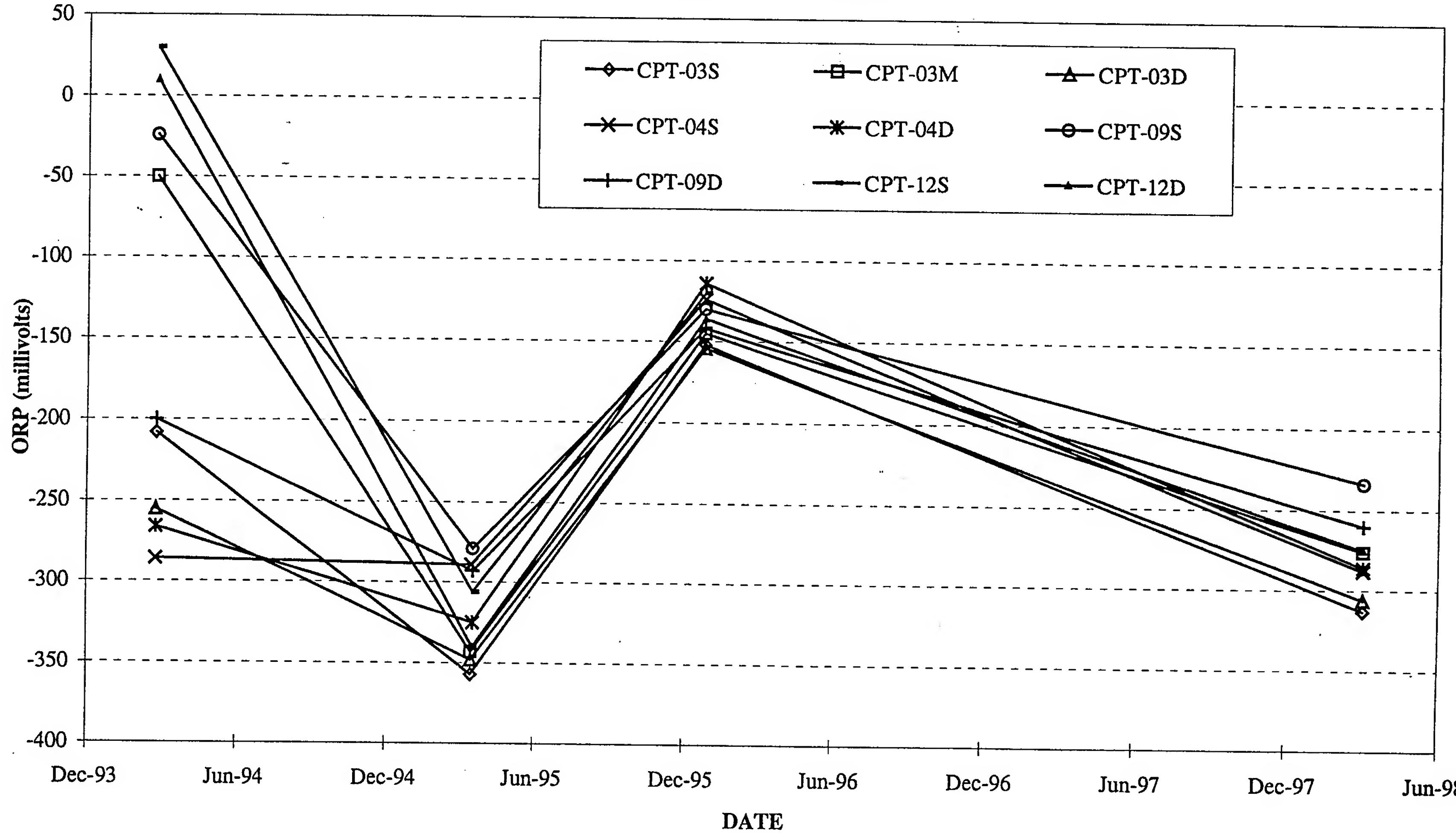
**FIGURE 7**
**OXIDATION-REDUCTION POTENTIAL OVER TIME**
**MARCH 1994 TO MARCH 1998**
**INTRINSIC REMEDIATION TREATABILITY STUDY ADDENDUM**
**SITE ST-29**
**PATRICK AFB, FLORIDA**

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inversely correlated to changes in BTEX concentration over the same time period (i.e., increases in ORP correspond to decreases in BTEX concentration, and vice versa). While the measurement of ORP in the field is sensitive to sampling protocol and equipment, an increase in ORP could be interpreted to be a result of decreased microbial activity due to decreasing dissolved BTEX concentrations, and vice-versa.

**Dissolved Oxygen**

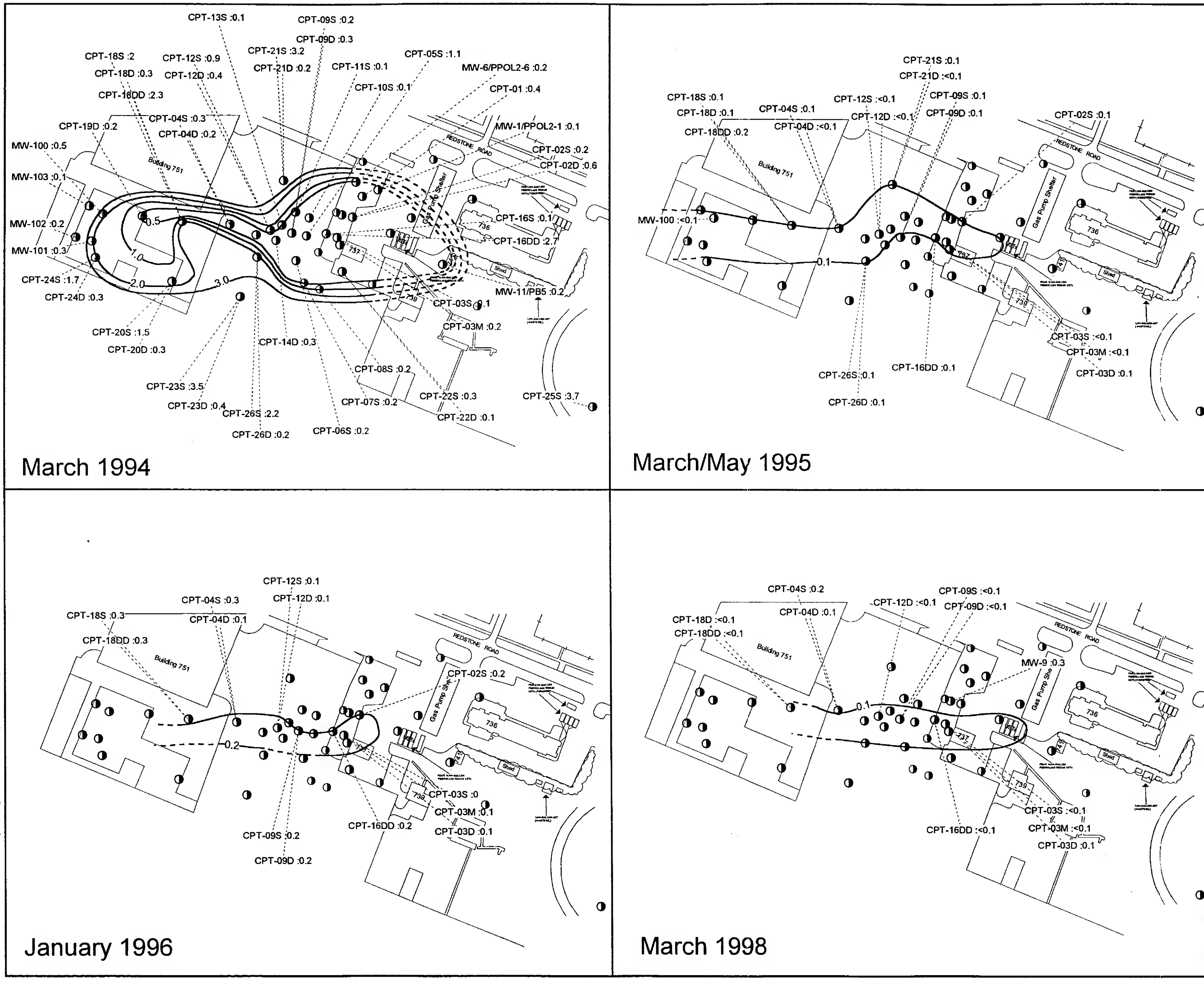
DO data collected at the site from 1994 to 1998 are summarized in Table 5. The areal distributions of DO at the site in 1994, 1995, 1996, and 1998 are presented on Figure 8, and the vertical distributions of DO within the plume core in 1994, 1995, 1996, and 1998 are plotted on Figure 9. DO concentrations range from less than 0.1 milligram per liter (mg/L) within the core of the BTEX plume to as high as 3.7 mg/L (CPT-25S in March 1994) outside of the BTEX plume. Comparison of Figures 3 and 4 with Figures 8 and 9 shows graphically that areas with elevated total BTEX concentrations have decreased DO concentrations. The correlation between depleted DO and elevated BTEX concentrations is a strong indication that aerobic biodegradation of the BTEX compounds has occurred at the site. The greatest aerobic activity is expected to occur at the upgradient perimeter of the source area and along the fringes of the plume, because these are areas where BTEX-contaminated groundwater interacts with groundwater containing measurable concentrations of DO.

**Nitrate+Nitrite**

After DO has been depleted in a microbiological treatment zone, nitrate may be used as an electron acceptor for anaerobic biodegradation of organic carbon via denitrification. Nitrate concentrations below background in areas with high organic carbon and low DO concentrations are indicative of denitrification. Nitrate plus nitrite (as nitrogen) data collected from monitoring locations at the site from 1994 to 1998 are summarized in Table 5. All nitrate concentrations in January 1996 were less than the detection limit of 0.05 mg/L. In March 1994, the highest nitrate+nitrite concentrations were detected within the BTEX plume. In contrast, the lowest concentrations of nitrate+nitrite detected in March 1995 and March 1998 were detected within the BTEX plume, suggesting that some BTEX degradation via denitrification was occurring. In any event, the overall lack of nitrate in groundwater at Site ST-29 indicates that denitrification is not contributing significantly to BTEX attenuation.

**Manganese**

Manganese data collected at the site from 1995 and 1998 are summarized in Table 5. Groundwater samples collected at the site during the March 1994 and January 1996 sampling events were not analyzed for manganese. A correlation between depleted manganese and elevated BTEX concentrations is an indication of the biodegradation of BTEX compounds by the process of manganese reduction. However, all manganese concentrations detected in samples from monitoring wells at Site ST-29 were 0.1 mg/L or less. Therefore, the lack of manganese in groundwater at Site ST-29 indicates that manganese reduction is not contributing significantly to BTEX attenuation.




## LEGEND

| | |
|---|---|
| MW-100 : 0.5 | Monitoring Location ID and Dissolved Oxygen Concentration (milligrams per liter) |
| 0.1 | Dissolved Oxygen Concentration Isopleth (milligrams per liter) |
| < 0.1 | Reported Value Less Than Specified Detection Limit |
| UST | Underground Storage Tank |
| AST | Aboveground Storage Tank |
| MOGAS | Motor Vehicle Gasoline |

NOTE: Where values from different depths differ, the value from the depth corresponding with the highest total BTEX concentration was used to generate contours.

0 100 200
Feet

N

**FIGURE 8**

**DISSOLVED OXYGEN IN GROUNDWATER**

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Patrick Air Force Base, Florida

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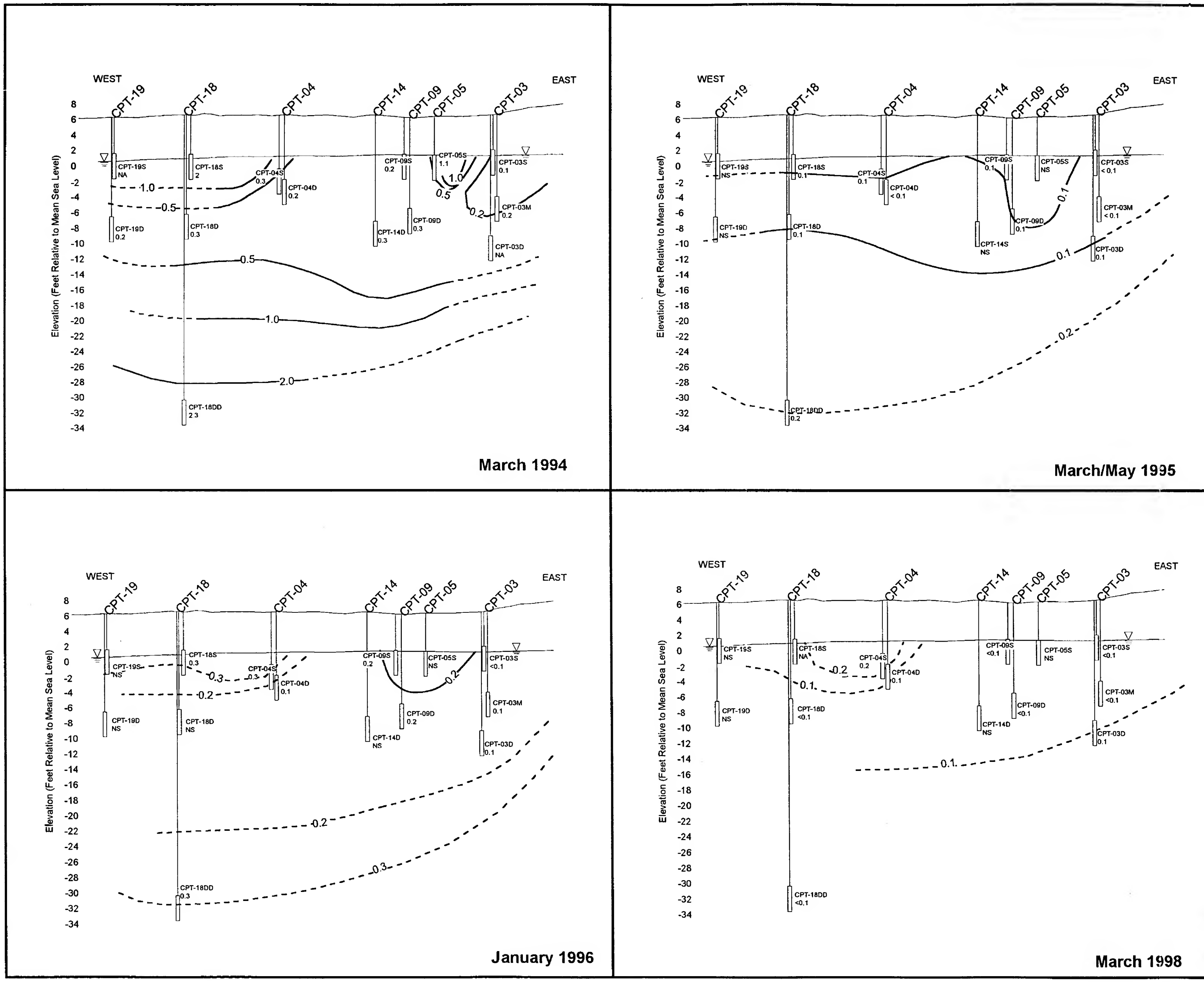


## LEGEND

| | |
|---|---|
| CPT-4S 1.53 | Monitoring Location Screen and Dissolved Oxygen Concentration (milligrams per liter) |
| 1.5 | Dissolved Oxygen Concentration Isopleth (Dashed where Inferred) |
| NA | Data Not Available |
| NS | Not Sampled |
| ▽ | Approximate Groundwater Surface |

0 50 100
Feet

FIGURE 9

**CROSS-SECTION OF DISSOLVED OXYGEN IN GROUNDWATER**

Site ST-29
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## Ferrous Iron

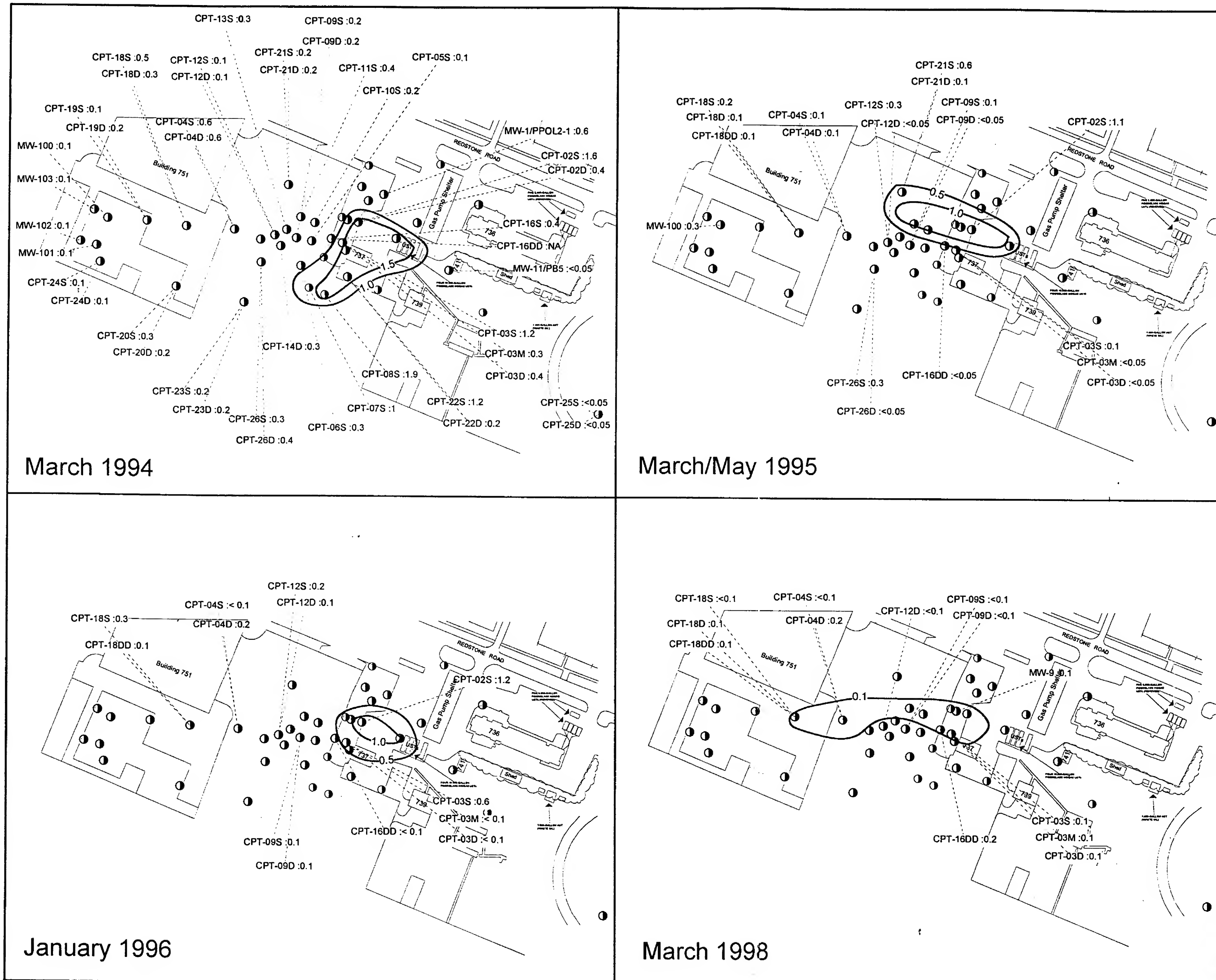
Dissolved ferrous iron ($Fe^{+2}$) is the reduced form of iron and is a byproduct of the oxidation of organic carbon (e.g., BTEX) via ferric iron ($Fe^{+3}$) reduction. Ferrous iron data collected at the site from 1994 to 1998 are summarized in Table 5. The areal distributions of ferrous iron at the site in 1994, 1995, 1996, and 1998 are presented on Figure 10. Comparison of Figure 3 with Figure 10 shows that areas with elevated total BTEX concentrations have elevated ferrous iron concentrations, with the highest ferrous iron concentrations occurring in the core of the dissolved BTEX plume, particularly in and around the source area. The continuing correlation between elevated ferrous iron and elevated BTEX concentrations is a strong indication that anaerobic biodegradation of the BTEX compounds has occurred over time at the site. However, ferrous iron concentrations in March 1998 were relatively low, suggesting that the process was less prominent at that time. The data are insufficient to ascertain whether this is a continuing trend.

The greatest anaerobic activity is expected to occur within the core of the plume, because this is the area where BTEX-contaminated groundwater is likely to be depleted of DO. Several sources suggest that the reduction of ferric iron to ferrous iron cannot proceed without microbial mediation (Lovley and Phillips, 1988; Lovley *et al.*, 1991; Chapelle, 1993); therefore, the presence of ferrous iron in the plume core strongly suggests that ferric iron is being used as an electron acceptor at the site during biodegradation of BTEX compounds.

## Sulfate

Sulfate may also be used as an electron acceptor during microbial degradation of natural or anthropogenic organic carbon under anaerobic conditions (Grbic-Galic, 1990). This ORP reaction is commonly called sulfate reduction, which results in a decrease in groundwater sulfate concentrations. Sulfate concentration data measured at the site between 1994 and 1998 are summarized in Table 5. The TS report (Parsons ES, 1995) concluded that sulfate concentrations did not exhibit an inverse relationship with BTEX concentrations, and that sulfate concentrations were elevated in areas containing elevated BTEX concentrations. These conclusions are generally supported by the more recent sampling data collected in 1995, 1996, and 1998. Sulfate concentrations in contaminated areas are generally similar to or higher than sulfate concentrations detected in upgradient and cross-gradient areas in 1994. For example, the sulfate concentrations at CPT-03S in March 1998 (12.6 mg/L) was higher than the concentration at CPT-03D (5.53 mg/L), despite the fact that the dissolved BTEX concentrations in CPT-03S and -03D were 22,400 μg/L and 1.5 μg/L, respectively. Similarly, the March 1998 sulfate concentration at CPT-04D (12.7 mg/L) (BTEX = 1,180 μg/L) was higher than at CPT-04S (6.2 mg/L) (BTEX = 9.1 μg/L). The background sulfate concentration in March 1994 was generally less than 5 mg/L.

The sulfate data do suggest that sulfate reduction may be occurring in very localized areas. For example, the January 1996 sulfate concentration at CPT-02S (BTEX = 139 μg/L) was less than 0.5 mg/L.




## LEGEND

| | |
|---|---|
| MW-100 : 0.1 | Monitoring Location ID and Ferrous Iron Concentration (milligrams per liter) |
| 0.5 | Ferrous Iron Concentration Isopleth (milligrams per liter) |
| < 0.05 | Reported Value Less Than Specified Detection Limit |
| UST | Underground Storage Tank |
| AST | Aboveground Storage Tank |
| MOGAS | Motor Vehicle Gasoline |

NOTE: Where values from different depths differ, the value from the depth corresponding with the highest total BTEX concentration was used to generate contours.

0 100 200
Feet

N

FIGURE 10

**FERROUS IRON IN GROUNDWATER**

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### Methane

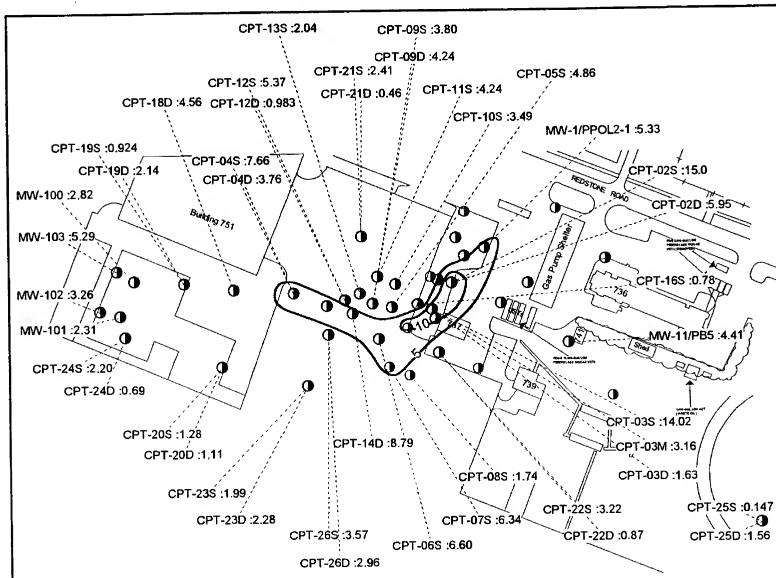
The presence of methane in BTEX-contaminated groundwater indicates that anaerobic biodegradation of BTEX is occurring via the microbially mediated process of methanogenesis (carbon dioxide reduction). Methane data collected at the site between 1994 and 1998 are summarized in Table 5. The areal distributions of methane at the site in March 1994, March 1995, and March 1998 are presented on Figure 11. Groundwater samples were not analyzed for methane during 1996. Comparison of Figure 3 with Figure 11 shows graphically that areas with elevated total BTEX concentrations have elevated methane concentrations, with the highest methane concentrations occurring in the core of the dissolved BTEX plume immediately downgradient from the USTs. The continued correlation between elevated methane and elevated BTEX concentrations is a strong indication that anaerobic biodegradation of the BTEX compounds continues to occur at the site. The greatest methanogenic activity is expected to occur within the core of the plume, because this is the area where BTEX-contaminated groundwater is more likely to be depleted of DO and other electron acceptors (e.g., ferric iron and sulfate). Comparison of methane concentrations over time at five sampling locations that were sampled in 1994, 1995, and 1998 (CPT-03S, CPT-09D, CPT18D, CPT-04S, CPT-04D) indicate that concentrations have been stable to increasing, indicating that the occurrence of methanogenesis has not diminished over time.

### Alkalinity

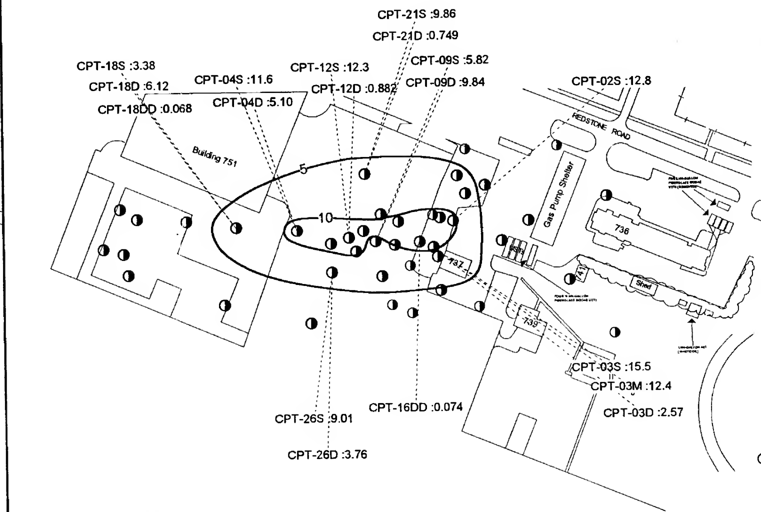
Alkalinity is a measure of the ability of groundwater to buffer changes in pH caused by the addition of biologically generated acids. Total alkalinity (measured as calcium carbonate [$CaCO_3$]) of groundwater samples collected at the site from 1994 to 1998 is summarized in Table 5. Groundwater contaminated by fuel hydrocarbons often exhibits total alkalinity that is higher than that of groundwater in background areas. An increase in alkalinity relative to background concentrations suggests that additional buffering capacity was generated to address acids produced during biodegradation of BTEX. Increases in alkalinity above background concentrations can be observed at Site ST-29. Alkalinities generally are below 300 mg/L in areas with low or non-detectable concentrations of dissolved BTEX, while more highly contaminated areas generally have alkalinity greater than 300 mg/L. The highest concentration of alkalinity detected at Site ST-29 was 920 mg/L at CPT-03S (March 1995). CPT-03S is located approximately 100 ft downgradient from the suspected source area, and has been the most contaminated well at the site. Groundwater from this monitoring point also had the highest alkalinity measured during the 1994 and 1996 sampling events. The data indicate that the alkalinity is sufficient to continue buffering the groundwater pH against the effects of biologically mediated BTEX oxidation reactions.

## 3.0 CONCLUSIONS

Results from groundwater monitoring conducted during January 1996 and March 1998 indicate that natural attenuation of BTEX continues at Site ST-29. The areal extent of the BTEX plume migration does not appear to have increased since 1994; rather, the plume extent appears to be stable or diminishing slightly. The distribution of electron acceptors/metabolic byproducts that are involved in biologically mediated redox reactions



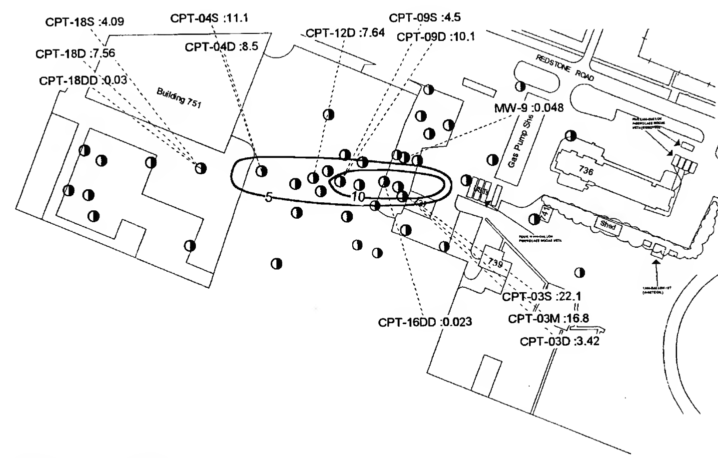

March 1994




March/May 1995

# NO DATA AVAILABLE

January 1996




March 1998

**LEGEND**

| | |
|---|---|
| MW-100 : 2.82 | Monitoring Location ID and Methane Concentration (milligrams per liter) |
| 10 | Methane Concentration Isopleth (milligrams per liter) |
| UST | Underground Storage Tank |
| AST | Aboveground Storage Tank |
| MOGAS | Motor Vehicle Gasoline |

NOTE: Where values from different depths differ, the value from the depth corresponding with the highest total BTEX concentration was used to generate contours.

0 100 200
Feet

N

**FIGURE 11**

**METHANE IN GROUNDWATER**

Site ST-29
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Patrick Air Force Base, Florida

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indicate that microbially-mediated redox reactions are continuing to occur within the BTEX plume. Data suggest that degradation of dissolved BTEX at the site is occurring via the biodegradation processes of aerobic respiration, methanogenesis, and to a lesser extent, iron reduction. Sulfate reduction also appears to be occurring, but only in very localized portions of the plume.

Monitoring results indicate that the Bioplume II models presented in the TS report (Parsons ES, 1995) underestimated the maximum concentration of dissolved BTEX that would be present in the plume over time, but that the downgradient extent of the plume is conservatively overestimated by both models. While the extent of the BTEX plume has not increased, the bioventing system does not appear to have had a significant impact on total dissolved BTEX concentrations. Although bioventing is effective in reducing soil BTEX concentrations in the vadose zone, the continued presence of elevated dissolved BTEX concentrations suggests that a residual source of BTEX persists within the capillary fringe or saturated zone (i.e., a smear zone). An increase in the average groundwater elevation of 0.4 foot from March 1994 to January 1996 further has increased the volume of saturated soil in the source area, decreased the volume of unsaturated soil subject to the effects of bioventing, and enhanced the dissolution of BTEX into the groundwater.

LTM should be continued to confirm stabilization of the dissolved BTEX plume and to document the continuing occurrence of microbially mediated biodegradation. LTM also is required to assess the effect of increasing dissolved BTEX concentrations with time along the center line of the plume (monitoring points CPT-03S, CPT-03M, and CPT-04D) on plume stability. If more rapid remediation is required, the engineering remediation of contaminated soils below the average water table (e.g., via biosparging) is recommended.

## 4.0 REFERENCES


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# APPENDIX A

# ANALYTICAL DATA

MANTECH

Ref: 96\LB16

February 9, 1996

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection and Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: S.A. Vandegrift SV

Dear Don:

Please find attached the analytical results for Service Request SF-2-186 requesting the analysis of Patrick AFB groundwater samples to be analyzed by purge-and-trap/GC-FID:PID for Benzene, Toluene, Ethylbenzene, p-, m-, & o-Xylene, 1,3,5-, 1,2,4-, & 1,2,3-Trimethylbenzene, and Total Fuel Carbon. We obtained your 10 groundwater samples in duplicate, in capped, 40 mL VOA autosampler vials on February 5, 1996, and they were analyzed on February 7-8, 1996. Samples were stored at 4°C until analyzed. All samples were acquired and processed using the Millennium data system. A 5 place (1-500 ppb) external standard curve was used to quantitate the samples for the compounds of interest.

RSKSOP-133, "Simultaneous Analysis of Aromatics and Total Fuel Carbon by Dual Column-Dual Detector for Ground Water Samples" was used for these analyses. Autosampling was performed using a Dynatech Precision autosampler system in line with a Tekmar LSC 2000 concentrator.

Sincerely,

Lisa R. Black

Lisa R. Black

xc: R. L. Cosby
G.B. Smith
J.T. Wilson
J.L. Seeley

Printed 2/9/96 SF-2-186

DP-PT/GC-FID:PID Analyses for Dr. Kampbell

Units = ng/mL Analyst: L. Black

| SampleName | BENZENE | TOLUENE | ETHYLBENZENE | p-XYLENE | m-XYLENE | o-XYLENE | 1,3,5-TMB | 1,2,4-TMB | 1,2,3-TMB | Fuel Carbon |
|---|---|---|---|---|---|---|---|---|---|---|
| 10 PPB | 9.9 | 9.7 | 9.5 | 9.7 | 9.5 | 9.6 | 9.5 | 9.5 | 9.6 | N/A |
| CPT-2S | 64.3 | 5.2 | 53.3 | 4.4 | 8.4 | 3.5 | 1.5 | 45.5 | 37.9 | 1500 |
| CPT-86-4D | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| CPT-86-4S | ND | ND | BLQ | BLQ | BLQ | BLQ | ND | ND | ND | BLQ |
| CPT-86-16DD | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| CPT-86-18DD | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| CPT-86-18S | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| CPT-86-12S | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| CPT-68-12S Duplicate | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| CPT-86-12~~M~~D | 5.0 | 5.2 | ND | 8.9 | 5.2 | 5.0 | BLQ | 1.6 | 5.4 | 625 |
| CPT-86-9S | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| CPT-86-9M | 28.9 | 10.4 | 1.9 | 6.2 | 5.5 | 6.5 | 1.2 | 1.2 | 7.8 | 914 |
| QC, OBSERVED, PPB | 46.8 | 45.5 | 49.5 | 46.2 | 46.4 | 46.6 | 45.9 | 46.0 | 46.5 | N/A |
| QC, TRUE VALUE, PPB | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | N/A |

ND = None Detected; BLQ = Below Limit of Quantitation, 1 ppb; N/A = Not Analyzed

MANAGEMENT TECHNOLOGY

Ref: 96-JH10/vg

February 14, 1996

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection & Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

DISSOLVED GASES

THRU: S.A. Vandegrift SV

Dear Don:

Find attached results for methane, ethylene and ethane on samples received February 5, 1996 under Service Request #SF-2-186 mod. 1. Samples were prepared and calculations done as per RSKSOP-175. Analyses were performed as per RSKSOP-147.

If you have any questions concerning this data, please contact me.

Sincerely,

Jeff Hickerson

Jeff Hickerson

xc: R.L. Cosby
G.B. Smith
J.L. Seeley

Patrick AFB - 1996 data

ManTech Environmental Research Services Corporation
R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

SR# SF-2-186
MOD 1

ANALYSIS PERFORMED 2-8-96

| SAMPLE | METHANE | ETHYLENE | ETHANE |
|---|---|---|---|
| LAB BLANK | BLQ | ND | ND |
| EPA-83-1 | 9.48 | ND | ND |
| EPA-83-2 | 16.19 | ND | BLQ |
| EPA-83-3 | 3.75 | ND | BLQ |
| EPA-83-4 | 11.68 | ND | BLQ |
| " LAB DUP | 10.71 | ND | ND |
| EPA-83-7 | 7.50 | ND | ND |
| " FIELD DUP | 7.38 | ND | ND |
| 10 PPM CH4 | 10.00 | NA | NA |
| 100 PPM CH4 | 100.11 | NA | NA |
| 1000 PPM CH4 | 999.93 | NA | NA |
| 1% CH4 | 1.02 | NA | NA |
| 10% CH4 | 10.00 | NA | NA |
| 20% CH4 | 20.28 | NA | NA |
| 10 PPM C2H4 | NA | 10.21 | NA |
| 100 PPM C2H4 | NA | 99.98 | NA |
| 10 PPM C2H6 | NA | NA | 10.24 |
| 100 PPM C2H6 | NA | NA | 99.98 |

LIMITS OF QUANTITATION.

| METHANE | ETHYLENE | ETHANE |
|---|---|---|
| 0.001 | 0.003 | 0.002 |

SAMPLE UNITS ARE mg/L.
STANDARDS UNITS CORRESPOND
TO THE SAMPLE COLUMN.

BLQ DENOTES BELOW LIMIT OF QUANTITATION.
ND DENOTES NONE DETECTED.
NA DENOTES NOT ANALYZED.

MANAGEMENT TECHNOLOGY

Ref: 96-TH4/vg
96-JRD5/vg

February 12, 1996

INORGANICS

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection & Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: S.A. Vandegrift SV

Dear Don:

Attached are the results of 13 Patrick AFB samples submitted to MERSC as part of Service Request #SF-2-186. The samples were received February 5, 1996 and analyzed immediately. The methods used for analysis were EPA Methods 353.1 for $NO_2$ and $NO_3$, 120.1 for Conductivity and Waters capillary electrophoresis Method for N-601 for $SO_4$. Quality assurance measures performed on this set of samples included spikes, duplicates, known AQC samples and blanks.

If you have any questions concerning these results, please feel free to contact us.

Sincerely,

Tim Hensley

Tim Hensley

Justin Daniel

Justin Daniel

xc: R.L. Cosby
G.B. Smith
J.L. Seeley

ManTech Environmental Research Services Corporation
R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

| Sample | Conductivity | mg/l $NO_2^-$+$NO_3^-$(N) | mg/l $SO_4^{-2}$ |
|---|---|---|---|
| CPT-3D | 693 | <.05 | 16.5 |
| CPT-3D Dup | 692 | ---- | ---- |
| CPT-3I | 695 | <.05 | 15.7 |
| CPT-3S | 1675 | <.05 | 10.0 |
| CPT-2S | 928 | <.05 | <.5 |
| CPT-86-4D | 660 | <.05 | 21.5 |
| CPT-86-4D Dup | ---- | ---- | 21.9 |
| CPT-86-4S | 482 | <.05 | 4.26 |
| CPT-86-9M | 990 | <.05 | 1.71 |
| CPT-86-9M Dup | 990 | ---- | ---- |
| CPT-86-9S | 378 | <.05 | 1.45 |
| CPT-86-12M | 988 | <.05 | 2.85 |
| CPT-86-12S | 465 | <.05 | <.5 |
| CPT-86-12S Dup | ---- | <.05 | ---- |
| CPT-86-16DD | 28,600 | <.05 | 278 |
| CPT-86-18DD | 26,200 | <.05 | 245 |
| CPT-86-18S | 633 | <.05 | 43.3 |
| | | | |
| Blank | ---- | <.05 | <.5 |
| AQC | ---- | 5.96 | 54.2 |
| AQC T.V. | ---- | 6.00 | 52.0 |
| Spike Rec. | ---- | 97% | 105% |

MANTECH

Ref: 96/JAD20

May 13, 1996

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection and Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

CHLORINATED VOAS, MTBE & BrCH2-CH2Br

THRU: S.A. Vandegrift SV

Dear Don:

As requested in Service Request # SF-2-186, headspace GC/MS analysis of 13 Patrick AFB water samples for Clorinated volatile organics, MTBE and 1,2-Dibromoethane was completed. The samples were received on February 5, 1996 and analyzed on March 19, 1996. RSKSOP-148 (Determination of Volatile Organic Compounds in Water by Automated Headspace Gas Chromatography/Mass Spectrometry (Saturn II Ion Trap Detector) was used for this analysis.

An internal standard calibration method was established for the 12 compounds. The standard curves were prepared from 1.0 to 200 ppb. The lower calibration limits were 1.0 ppb.

The method detection limit (MDL) for 1,2-Dibromoethane for these analyses was determined, according to RSKSOP-148, to be 0.09 ppb.

A dilution corrected quantitation report for the samples, lab duplicates, field duplicates, QC standards and lab blanks is presented in table 1-2.

If you should have any questions, please feel free to contact me.

Sincerely,

John Allen Daniel

John Allen Daniel

xc: R.L. Cosby
G.B. Smith
D.D. Fine
J.L. Seeley
J.T. Wilson

# Table 1. Quantitation Report for S.R.# SF–2–186 from Patrick AFB.

Concentration = ppb

| Compound | CPT–2S | CPT–2S 1/4 Dil Field Dup | CPT–3S | CPT–3S 1/40 Dil Field Dup | CPT–3I | CPT–3D | CPT–86 4S | CPT–86 4D | CPT–86 9S | CPT–86 9MD |
|---|---|---|---|---|---|---|---|---|---|---|
| VINYL CHLORIDE | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 1,1–DICHLOROETHENE | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| T–1,2–DICHLOROETHENE | ND | ND | ND | ND | ND | ND | ND | ND | ND | ***** |
| METHYL–Tert–BUTYL ETHER | ***** | 514 | 101 | 128 | 7.6 | 15.9 | 1.4 | 53.3 | ND | ND |
| 1,1–DICHLOROETHANE | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| C–1,2–DICHLOROETHENE | ND | ND | ND | ND | ND | ND | --- | ND | ND | ND |
| 1,1,1–TRICHLOROETHANE | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| CARBON TETRACHLORIDE | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 1,2–DICHLOROETHANE | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| TRICHLOROETHENE | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| TETRACHLOROETHENE | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 1,2–DIBROMOETHANE | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |

| Compound | CPT–86 9MD 1/4 Dil Field Dup | CPT–86 12S | CPT–86 12S Lab Dup | CPT–86 12MD | CPT–86 12MD 1/2 Dil Field Dup | CPT–86 16DD | CPT–86 18S | CPT–86 18DD | QC0319D 50 ppb | QC0319E 20 ppb |
|---|---|---|---|---|---|---|---|---|---|---|
| VINYL CHLORIDE | ND | ND | ND | ND | ND | ND | ND | ND | ** | 21.7 |
| 1,1–DICHLOROETHENE | ND | ND | ND | ND | ND | ND | ND | ND | ** | 22.8 |
| T–1,2–DICHLOROETHENE | ND | ND | ND | ND | ND | ND | ND | ND | ** | 20.4 |
| METHYL–Tert–BUTYL ETHER | 353 | ND | ND | ***** | 348 | ND | ND | ND | 47.1 | ** |
| 1,1–DICHLOROETHANE | ND | ND | ND | ND | ND | ND | ND | ND | ** | 22.4 |
| C–1,2–DICHLOROETHENE | ND | ND | ND | ND | ND | ND | ND | ND | ** | 21.2 |
| 1,1,1–TRICHLOROETHANE | ND | ND | ND | ND | ND | ND | ND | ND | ** | 20.8 |
| CARBON TETRACHLORIDE | ND | ND | ND | ND | ND | ND | ND | ND | ** | 20.3 |
| 1,2–DICHLOROETHANE | ND | ND | ND | ND | ND | ND | ND | ND | ** | 21.6 |
| TRICHLOROETHENE | ND | ND | ND | ND | ND | ND | ND | ND | 45.7 | 23.3 |
| TETRACHLOROETHENE | ND | ND | ND | ND | ND | ND | ND | ND | ** | 15.4 |
| 1,2–DIBROMOETHANE | ND | ND | ND | ND | ND | ND | ND | ND | 45.8 | ** |

ND = None Detected   Dil = Dilution   Dup = Duplicate   ***** = Above Calibration Limit(200 ppb)   ** = Not In QC   QC = Quality Control Std.

# Table 2. Quantitation Report for S.R. # SF-2-186 from Patrick AFB.

Concentration = ppb

| Compound | QC0319F 200 ppb | QC0319G 100 ppb | QC0319H 50 ppb | QC0319I 20 ppb | QC0319J 200 ppb | QC0319K 100 ppb | BL0319A | BL0319B |
|---|---|---|---|---|---|---|---|---|
| VINYL CHLORIDE | ** | 96.7 | ** | 23.5 | ** | 102 | ND | ND |
| 1,1-DICHLOROETHENE | ** | 98.9 | ** | 23.7 | ** | 93.4 | ND | ND |
| T-1,2-DICHLOROETHENE | ** | 89.6 | ** | 21.0 | ** | 92.7 | ND | ND |
| METHYL-tert-BUTYL-ETHE | 182 | ** | 52.2 | ** | 175 | ** | ND | ND |
| 1,1-DICHLOROETHANE | ** | 96.2 | ** | 23.1 | ** | 108 | ND | ND |
| C-1,2-DICHLOROETHENE | ** | 90.7 | ** | 21.3 | ** | 106 | ND | ND |
| 1,1,1-TRICHLOROETHANE | ** | 98.7 | ** | 22.6 | ** | 96.5 | ND | ND |
| CARBON TETRACHLORIDE | ** | 94.7 | ** | 22.1 | ** | 91.3 | ND | ND |
| 1,2-DICHLOROETHANE | ** | 91.1 | ** | 22.2 | ** | 120 | ND | ND |
| TRICHLOROETHENE | 213 | 110 | 50.9 | 25.1 | 177 | 100 | ND | ND |
| TETRACHLOROETHENE | ** | 76.4 | ** | 16.9 | ** | 77.4 | ND | ND |
| 1,2-DIBROMOETHANE | 214 | ** | 59.6 | ** | 203 | ** | ND | ND |

ND = None Detected ** = Not In QC QC = Quality Control Std BL = Blank

MANAGEMENT TECHNOLOGY

Ref: 96-SH10/vg

February 13, 1996

TOC

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection & Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: S.A. Vandegrift SV

Dear Don:

Attached are TOC results for 14 liquids submitted February 9, 1996 under Service Request #SF-2-186. Sample analysis was begun and completed February 12, 1996 using RSKSOP-102.

Blanks, duplicates and AQC samples were analyzed along with your samples, as appropriate, for quality control. If you have any questions concerning this data, please feel free to ask me.

Sincerely,

Sharon Hightower

Sharon Hightower

xc: R.L. Cosby
G.B. Smith
J.L. Seeley JS

ManTech Environmental Research Services Corporation
R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

KAMPBELL--PATRICK--SF-2-186

| SAMPLE | MG/L TOC |
|---|---|
| CPT-2S | 14.9 |
| CPT-3D REP 2 | 9.1 |
| CPT-3I | 10.4 |
| CPT-3S REP 1 | 119 |
| CPT-3S REP 1 DUP | 119 |
| CPT-3S REP 2 | 141 |
| CPT-86-4D | 4.9 |
| CPT-86-4S | 4.2 |
| CPT-86-9M | 26.7 |
| CPT-86-9S | 1.5 |
| CPT-86-12M | 14.8 |
| CPT-86-12S | 1.7 |
| CPT-86-16D | 4.2 |
| CPT-86-18DD | 5.3 |
| CPT-86-18S | 3.3 |
| WPO34-II | 6.1 |

WPO34-II t.v.=6.30

MANTECH

Ref: 96-DF10

Feb. 26, 1996

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection and Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: S.A. Vandegrift SV

Dear Don:

As requested in Service Request SF-2-186, GC/MS analysis for phenols and aliphatic/aromatic acids was done on water samples from well sites, CPT-86-3S and -3D, at Patrick AFB. Derivatization of the sample was done by Amy Zhao on Feb. 8, 1995. The extract was analyzed by GC/MS on Feb. 23, 1996. RSKERL SOP 177 was used for the extraction, derivatization and GC/MS analysis of the samples.

Table I provides the concentrations of the phenols and aliphatic/aromatic acids found in the Patrick AFB samples. A derivative and extraction blank and a 50 ppb spiked extraction blank are also included. 3,4- and 3,5-dimethyl benzoic acid were found at the highest concentration at 670 and 262 ppb, respectfully. Methybenzoic acids, dimethylphenols and cresols were found in the sample and are quantified in Table I. Please note that 2-ethylhexanoic acid was present in one of the extraction blanks at levels higher than found in the samples.

Enclosed please find chromatograms of the PFB derivative of compounds found in water sample CPT-86-3S. Each of the peaks listed in Table I are labelled in the chromatogram. Other chromatograms show ions characteristic of $C_7$, $C_8$, $C_9$, and $C_{10}$ aliphatic acids.

If you should have any questions, please feel free to contact me.

Sincerely,

Dennis D Fine

Dennis D. Fine

xc: J. Seeley
G. Smith
R. Cosby
D. Fine

ManTech Environmental Research Services Corporation
R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

Table I. Quantitative Report and QC Data for Phenols and Aliphatic and Aromatic Acids for Samples from Patrick AFB (Service Request SF-2-186).

| | | Concentration ppb | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | CPT-86-3S | CPT-86-3D | Extraction Blank | Extraction Blank | Standard Blank | Standard Blank | Standard Blank |
| 1 | PROPANOIC ACID - PFB | 16 | *** | 6 | 81 | 6 | 46 | 6 |
| 2 | 2-METHYLPROPANOIC ACID - PFB | 14 | *** | *** | *** | *** | 20 | *** |
| 3 | TRIMETHYL ACETIC ACID - PFB | 6 | *** | *** | *** | *** | 12 | *** |
| 4 | BUTYRIC ACID - PFB | 15 | 5 | 16 | *** | 14 | 40 | 20 |
| 5 | 2-METHYLBUTYRIC ACID - PFB | 10 | *** | *** | *** | *** | *** | *** |
| 6 | 3-METHYLBUTYRIC ACID - PFB | 9 | *** | *** | *** | *** | *** | *** |
| 7 | 3,3-DIMETHYLBUTYRIC ACID - PFB | 19 | *** | *** | N.F. | N.F. | *** | *** |
| 8 | PENTANOIC ACID - PFB | 20 | 12 | 64 | 9 | 47 | 15 | 70 |
| 9 | 2,3-DIMETHYLBUTYRIC ACID - PFB | *** | *** | *** | N.F. | N.F. | *** | *** |
| 10 | 2-ETHYLBUTYRIC ACID - PFB | *** | N.F. | *** | N.F. | N.F. | N.F. | *** |
| 11 | 2-METHYLPENTANOIC ACID - PFB | *** | N.F. | *** | *** | N.F. | N.F. | *** |
| 12 | 3-METHYLPENTANOIC ACID - PFB | 5 | *** | *** | N.F. | N.F. | *** | *** |
| 13 | 4-METHYLPENTANOIC ACID - PFB | *** | N.F. | *** | N.F. | N.F. | N.F. | *** |
| 14 | HEXANOIC ACID - PFB | 31 | 18 | 75 | 25 | 29 | 18 | 73 |
| 15 | 2-METHYLHEXANOIC ACID - PFB | *** | N.F. | *** | N.F. | N.F. | N.F. | N.F. |
| 16 | PHENOL - PFB | 31 | 7 | *** | *** | *** | N.F. | *** |
| 17 | CYCLOPENTANECARBOXYLIC ACID - PFB | 10 | N.F. | N.F. | N.F. | N.F. | N.F. | *** |
| 18 | 5-METHYLHEXANOIC ACID - PFB | *** | N.F. | N.F. | N.F. | N.F. | N.F. | N.F. |
| 19 | o-CRESOL - PFB | 9 | N.F. | N.F. | N.F. | N.F. | N.F. | N.F. |
| 20 | 2-ETHYLHEXANOIC ACID - PFB | 367 | 261 | 47 | 5 | 24 | 70 | 54 |
| 21 | HEPTANOIC ACID - PFB | 8 | *** | 19 | 9 | 5 | 12 | 15 |
| 22 | m-CRESOL - PFB | *** | N.F. | N.F. | N.F. | N.F. | N.F. | N.F. |
| 23 | p-CRESOL - PFB | 43 | N.F. | N.F. | N.F. | N.F. | N.F. | N.F. |
| 24 | 1-CYCLOPENTENE-1-CARBOXYLIC ACID - PFB | *** | N.F. | *** | N.F. | N.F. | N.F. | *** |
| 25 | o-ETHYLPHENOL - PFB | 7 | N.F. | N.F. | N.F. | N.F. | N.F. | N.F. |
| 26 | CYCLOPENTANEACETIC ACID - PFB | *** | N.F. | N.F. | N.F. | N.F. | N.F. | N.F. |
| 27 | 2,6-DIMETHYLPHENOL - PFB | 21 | N.F. | N.F. | N.F. | N.F. | N.F. | N.F. |
| 28 | 2,5-DIMETHYLPHENOL - PFB | 45 | N.F. | N.F. | N.F. | N.F. | N.F. | N.F. |
| 29 | CYCLOHEXANECARBOXYLIC ACID - PFB | *** | N.F. | N.F. | N.F. | N.F. | N.F. | *** |
| 30 | 3-CYCLOHEXENE-1-CARBOXYLIC ACID - PFB | *** | N.F. | N.F. | N.F. | N.F. | N.F. | N.F. |
| 31 | 2,4-DIMETHYLPHENOL - PFB | 37 | N.F. | N.F. | N.F. | N.F. | N.F. | N.F. |
| 32 | 3,5-DIMETHYLPHENOL & M-ETHYLPHENOL - PFB | 25 | N.F. | N.F. | N.F. | N.F. | N.F. | N.F. |
| 33 | OCTANOIC ACID - PFB | *** | *** | 10 | 5 | *** | 7 | 8 |
| 34 | 2,3-DIMETHYLPHENOL - PFB | 154 | *** | N.F. | N.F. | N.F. | N.F. | N.F. |
| 35 | p-ETHYLPHENOL - PFB | 7 | *** | N.F. | N.F. | N.F. | N.F. | N.F. |
| 36 | BENZOIC ACID - PFB | 19 | 71 | 7 | 8 | 5 | 5 | 6 |
| 37 | 3,4-DIMETHYLPHENOL - PFB | 16 | N.F. | N.F. | N.F. | N.F. | N.F. | N.F. |
| 38 | m-METHYLBENZOIC ACID - PFB | 45 | N.F. | *** | N.F. | N.F. | N.F. | N.F. |
| 39 | 1-CYCLOHEXENE-1-CARBOXYLIC ACID - PFB | N.F. | N.F. | N.F. | N.F. | N.F. | N.F. | N.F. |
| 40 | CYCLOHEXANEACETIC ACID - PFB | *** | N.F. | N.F. | N.F. | N.F. | N.F. | N.F. |
| 41 | 2-PHENYLPROPANOIC ACID - PFB | *** | N.F. | N.F. | N.F. | N.F. | N.F. | N.F. |
| 42 | o-METHYLBENZOIC ACID - PFB | 8 | N.F. | N.F. | *** | N.F. | N.F. | *** |
| 43 | PHENYLACETIC ACID - PFB | 49 | *** | *** | *** | *** | *** | *** |
| 44 | m-TOLYLACETIC ACID - PFB | 27 | N.F. | N.F. | N.F. | N.F. | N.F. | N.F. |
| 45 | o-TOLYLACETIC ACID - PFB | 5 | N.F. | N.F. | N.F. | N.F. | N.F. | N.F. |
| 46 | 2,6-DIMETHYLBENZOIC ACID - PFB | 14 | N.F. | N.F. | N.F. | N.F. | N.F. | N.F. |
| 47 | p-TOLYLACETIC ACID - PFB | 26 | *** | N.F. | N.F. | N.F. | N.F. | N.F. |
| 48 | p-METHYLBENZOIC ACID - PFB | 135 | *** | N.F. | N.F. | N.F. | N.F. | *** |
| 49 | 3-PHENYLPROPANOIC ACID - PFB | 5 | N.F. | N.F. | N.F. | N.F. | N.F. | N.F. |
| 50 | 2,5-DIMETHYLBENZOIC ACID - PFB | 21 | N.F. | *** | N.F. | N.F. | N.F. | N.F. |
| | DECANOIC ACID - PFB | *** | *** | 5 | *** | *** | 10 | *** |
| | 2,4-DIMETHYLBENZOIC ACID - PFB | N.F. | *** | N.F. | N.F. | N.F. | N.F. | *** |
| 53 | 3,5-DIMETHYLBENZOIC ACID - PFB | 262 | *** | N.F. | N.F. | N.F. | N.F. | N.F. |
| | 2,3-DIMETHYLBENZOIC ACID - PFB | 79 | N.F. | N.F. | N.F. | N.F. | N.F. | N.F. |
| | 4-ETHYLBENZOIC ACID - PFB | 40 | N.F. | N.F. | N.F. | N.F. | N.F. | N.F. |
| 56 | 2,4,6-TRIMETHYLBENZOIC ACID - PFB | 92 | 9 | N.F. | N.F. | N.F. | N.F. | N.F. |
| 57 | 3,4-DIMETHYLBENZOIC ACID - PFB | 670 | *** | N.F. | N.F. | N.F. | N.F. | N.F. |
| 58 | 2,4,5-TRIMETHYLBENZOIC ACID - PFB | 67 | N.F. | N.F. | N.F. | N.F. | N.F. | N.F. |

*** Indicates concentration of extract was below lowest calibration standard (5 ppb).
N.F. Indicates not found.

# Patrick AFB SF-2-186 Water Samples 1/30/96

| Sample | ∇, TOC feet | D.O. mg/L | Temp. °C | pH | ORP mV | $Fe^{++}$ mg/L | $H_2S$ mg/L | Alk. mg/L $CO_2$ | Cond. µS |
|---|---|---|---|---|---|---|---|---|---|
| CPT-86-16DD | 3.86 | 0.2 | 26.9 | 7.2 | -45 | <.1 | 0.3 | 380 | 8700 |
| -2S | 4.48 | 0.2 | 24.7 | 7.5 | -60 | 1.2 | 0.5 | 490 | 870 |
| -3S | 4.11 | 0.0 | 23.6 | 6.9 | -152 | 0.6 | 30. | 500 | 1270 |
| -3D | 4.16 | 0.1 | 26.4 | 7.2 | -154 | <.1 | 6.0 | 280 | 599 |
| -3M | N.M. | 0.1 | 25.1 | 6.9 | -145 | <.1 | 6.0 | 290 | 662 |
| -18S | 4.38 | 0.3 | 24.7 | 6.9 | -85 | 0.3 | 0.6 | 220 | 551 |
| -18DD | 4.55 | 0.3 | 26.7 | 7.5 | -55 | 0.1 | 0.1 | 270 | 11000 |
| -4S | 4.06 | 0.3 | 24.8 | 7.1 | -124 | <.1 | 2.0 | 170 | 522 |
| -4D | 4.11 | 0.1 | 25.2 | 6.9 | -114 | 0.2 | 12. | 260 | 657 |
| -12S | 4.06 | 0.1 | 24.4 | 7.0 | -120 | 0.2 | 0.2 | 180 | 474 |
| -12M | N.M. | 0.1 | 26.0 | 7.1 | -136 | 0.1 | 14. | 320 | 940 |
| -9S | 4.00 | 0.2 | 24.0 | 6.9 | -130 | 0.1 | 16. | 170 | 386 |
| -9M | N.M. | 0.2 | 25.3 | 7.2 | -142 | 0.1 | 18. | 350 | 706 |

SF-2-186

Monitoring Wells

| ...ple | TOC (in hde) | D.O. (mg/L) | Temp (°C) | pH | ORP | $Fe^{++}$ | $H_2S$ | Alk | Cond. (mS) |
|---|---|---|---|---|---|---|---|---|---|
| 86-16DD | 3.96 | 0.2 | 26.9 | 7.2 | -45 | <.1 | 0.3 | 380 | 8.7 mS |
| 86-2S | 4.48 | 0.2 | 24.7 | 7.5 | -60 | 1.2 | 0.5 | 480 | 870 µS |
| 86-3S | 4.11 | 0.0 | 23.6 | 6.9 | -152 | 0.6 | 30 | 500 | 1272 µS |
| -86-3D | 4.16 | 0.1 | 26.4 | 7.2 | -154 | <.1 | 6.0 | 280 | 599 µS |
| -86-3M | screen pt Tubing | 0.1 | 25.1 | 6.9 | -145 | <.1 | 6.0 | 290 | 662 µ |
| -86-18S | 4.38 | 0.3 | 24.7 | 6.9 | -85 | 0.3 | 0.6 | 220 | 551 µS |
| -86-18DD | 4.55 | 0.3 | 26.7 | 7.5 | -55 | 0.1 | 0.1 | 270 | 11.0 mS ~~11.0 mS~~ |
| 86-4S | 4.06 | 0.3 | 24.8 | 7.1 | -124 | <.1 | 2.0 | 170 | 522 µS |
| -86-4D | 4.11 | 0.1 | 25.2 | 6.9 | -114 | 0.2 | 12. | 260 | 654 µ |
| 86-12S | 4.06 | 0.1 | 24.4 | 7.0 | -120 | 0.2 | 0.2 | 180 | 474 µ |
| 86-12M | small Tubing | 0.1 | 26.0 | 7.1 | -136 | 0.1 | 14. | 320 | 940 µ |
| 86-9S | 4.00 | 0.2 | 24.0 | 6.9 | -130 | 0.1 | 16. | 170 | 386 µ |
| 86-9M | small Tubing | 0.2 | 25.3 | 7.2 | -142 | 0.1 | 18 | 350 | 706 µS |

FR

Continued on Page

Read and Understood By

Signed Date Signed Date

MANAGEMENT TECHNOLOGY

Ref: 98-MB20
March 20, 1998

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection and Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: Steve Vandegrift SV

Dear Don:

Please find attached the analytical results for Service Request SF-4-312 requesting the analysis of aqueous samples from Patrick AFB, FL to be analyzed for MTBE, BTEXXX and TMBs. The 14 samples were received in capped, 40 mL VOA vials on March 17, 1998. The samples were analyzed on March 18 and 19, 1998. All samples were acquired using the Millennium data system. A 6 point (1-1200 ppb) external calibration curve was used to determine the concentration for all compounds.

RSKSOP-122 "Analysis of Volatile Aromatic Hydrocarbons with Separation of Xylene Isomers by Purge & Trap Gas Chromatography" was used for these analyses. Auto-sampling was performed using a Dynatech Precision autosampler system in line with a Tekmar LSC 2000 concentrator.

Sincerely,

Mark Blankenship

Mark Blankenship

xc: R.L. Cosby
J.L. Seeley
G.B. Smith

ManTech Environmental Research Services Corporation

R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

Printed 03/20/98 SF-4-312

Analyses for Dr. Kampbell

Units = ng/ml Analyst M. Blankenship

| AMPLE NAME | MTBE | BENZENE | TOLUENE | ETHYLBENZENE | p-XYLENE | m-XYLENE | o-XYLENE | 1,3,5-TMB | 1,2,4-TMB | 1,2,3-TMB |
|---|---|---|---|---|---|---|---|---|---|---|
| :C, OBSERVED, 20 PPB | 21.3 | 22.0 | 21.9 | 21.8 | 21.7 | 21.4 | 22.6 | 23.0 | 22.4 | 19.5 |
| :C, TRUE VALUE, 20 PPB | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 |
| 00 PPB STD | 100.8 | 107.1 | 112.6 | 113.3 | 112.5 | 102.7 | 114.0 | 103.5 | 106.3 | 113.5 |
| :C LAB BLANK | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| :PT-86-3D | BLQ | 1.5 | BLQ | BLQ | BLQ | BLQ | ND | BLQ | BLQ | BLQ |
| :PT-4D | 2.5 | 1.3 | 2.3 | ND | 1170.4 | ND | 4.8 | 2.0 | 10.2 | 1.8 |
| :PT-4S | 1.2 | BLQ | BLQ | 3.7 | 3.2 | 2.2 | BLQ | BLQ | 1.8 | BLQ |
| :PT-18D D | ND | BLQ | BLQ | 1.2 | 1.3 | 1.1 | BLQ | ND | BLQ | ND |
| :PT-18M D | 1.5 | ND | ND | BLQ | BLQ | BLQ | BLQ | ND | BLQ | ND |
| :PT-18S | ND | ND | ND | BLQ | BLQ | BLQ | ND | ND | BLQ | ND |
| :PT-16DD | ND | ND | ND | BLQ | BLQ | BLQ | BLQ | ND | BLQ | ND |
| /W-9 | ND | BLQ | BLQ | BLQ | BLQ | BLQ | BLQ | BLQ | BLQ | BLQ |
| /W-9 DUPLICATE | ND | BLQ | ND | BLQ | BLQ | BLQ | BLQ | BLQ | BLQ | BLQ |
| /W-9D | 31.3 | 14.1 | 6.9 | BLQ | 4.4 | 7.5 | 6.0 | BLQ | 1.2 | 5.8 |
| 000 PPB STD | 1043.0 | 1099.0 | 1104.0 | 1124.0 | 1115.0 | 1102.0 | 1093.0 | 1098.0 | 1106.0 | 1100.0 |
| 3C LAB BLANK | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| /W-9S | 2.8 | BLQ | ND | BLQ | BLQ | BLQ | BLQ | ND | ND | BLQ |
| CPT-12D | 68.4 | 5.0 | 6.8 | BLQ | 14.9 | 6.7 | 4.9 | BLQ | BLQ | 4.1 |
| CPT-12S | ND | ND | ND | ND | BLQ | ND | ND | ND | ND | ND |
| CPT-86-3M | 3.5 | 214.7 | 240.0 | 1045.1 | 1509.4 | 1055.1 | 1042.4 | 373.9 | 1586.7 | 275.9 |
| CPT-86-3S | BLQ | 691.8 | 1864.2 | 3957.1 | 5153.2 | 6466.4 | 4316.7 | 1249.5 | 4861.6 | 942.0 |

ND = None Detected; BLQ = Below Limit of Quantitation, 1ppb

MANAGEMENT TECHNOLOGY

Ref. 98-MW28/ck
98-BS26/ck

March 31, 1998

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection & Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74821-1198

THRU: S.A. Vandegrift SV

Dear Don:

Attached are the results of 14 field samples from Patrick AFB submitted to MERSC as part of S.R. #SF-4-312. The samples were received 3/18/98 and analyzed 3/19/98. The methods used for analysis were Lachat FIA methods 10-107-06-1-A for $NH_3$, 10-107-04-2-A for $NO_2 + NO_3$, and Waters capillary electrophoresis method N-601 for Cl and $SO_4$.

Quality assurance measures performed on this set of samples included spikes, duplicates, known AQC samples, and blanks.

If you have any questions concerning these results, please feel free to contact us.

Sincerely,

Mark White

Mark White

Mark White BS

Brad Scroggins

xc: R.L. Cosby
J.L. Seeley
G.B. Smith

PATRICK AFB

| Sample | mg/L $Cl^-$ | mg/L $SO_4^{-2}$ | mg/L $NO_2^-+NO_3^-(N)$ | mg/L $NH_3(N)$ |
|---|---|---|---|---|
| CPT-4D | 17.0 | 12.7 | <.1 | 2.11 |
| CPT-45 | 15.4 | 6.21 | <.1 | 2.00 |
| CPT-86-3S | 64.5 | 12.6 | .25 | 1.29 |
| CPT-86-3M | 40.9 | 46.4 | <.1 | 3.91 |
| CPT-86-3D | 33.9 | 5.53 | <.1 | 1.36 |
| CPT-18S | 10.3 | 10.8 | <.1 | .47 |
| CPT-18M | 20.4 | 2.05 | (<.1)(<.1) | (1.38)(1.42) |
| CPT-18D | 8900 | 1040 | <.1 | 16.8 |
| CPT-86-16DD | 10,000 | 1020 | <.1 | 17.0 |
| MW-9 | 2.68 | 4.00 | <.1 | <.1 |
| CPT-9S | 7.64 | 7.88 | <.1 | 1.09 |
| CPT-9D | 38.7 | 3.69 | <.1 | 2.32 |
| CPT-12S | NS | NS | NS | NS |
| CPT-12D | 47.2 | 7.70 | <.1 | 2.13 |
| BLANK | <.05 | <.05 | <.1 | <.1 |
| AQC | 34.7 | 45.0 | .60 | .26 |
| TRUE VALUE | 34.8 | 44.0 | .62 | .26 |
| SPIKE REC. | 103% | 104% | 104% | 101% |

NS= NO SAMPLE

MANTECH
TECHNOLOGY

Ref: 98-LH25

March 27, 1998

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection and Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: S.A. Vandegrift SV

Dear Don:

As requested in Service Request #SF-4-312, gas analysis was performed for methane, ethylene, and ethane on samples from Patrick AFB. The samples were received on March 17, 1998. The analyses were performed on March 17 and 18, 1998. These analyses were performed as per RSKSOP-194, and the calculations were done as per RSKSOP-175.

If you should have any questions, please feel free to contact me.

Sincerely,

Lisa C Hopkins

Lisa Hopkins

xc: R.L. Cosby
J.T. Wilson
K. Hurt
G.B. Smith
J.L. Seeley

ManTech Environmental Research Services Corporation

R.S. Kerr Environmental Research Laboratory, P.O. Box 1198, 919 Research Drive
Ada, Oklahoma 74821-1189 405-436-8660 FAX 405-436-8501

SF-4-312 03/17/98
Patrick AFB

| Sample | Methane | Ethylene | Ethane |
|---|---|---|---|
| 100ppm CH4 | 92.2 | ** | ** |
| 100ppm C2H4 | ** | 105.1 | ** |
| 100ppm C2H6 | ** | ** | 110.9 |
| HPHe | ** | ** | ** |
| Lab Blank | ** | ** | ** |
| CPT-4S | 11.1 | ** | ** |
| CPT-4D | 8.50 | ** | ** |
| CPT-86-3S | 22.1 | ** | 0.019 |
| CPT-86-3M | 16.8 | ** | 0.010 |
| CPT-86-3D | 3.42 | ** | * |
| CPT-86-3D Lab Dup | 3.40 | ** | ** |
| MW-9 | 0.048 | ** | ** |
| CPT-9S | 4.50 | ** | ** |
| CPT-9D | 10.1 | ** | 0.008 |
| CPT-9D Field Dup | 10.4 | ** | 0.008 |
| 10ppm C2H6 | ** | ** | 10.4 |
| 100ppm CH4 | 92.3 | ** | ** |
| 100ppm C2H4 | ** | 90.2 | ** |
| 100ppm C2H6 | ** | ** | 101.9 |

Lower Limit of Quantitation

| | | | |
|---|---|---|---|
| | 0.001 | 0.003 | 0.002 |

Units for the samples are mg/L dissolved in water.
Units for the standards are parts per million.

** denotes None Detected.
* denotes Below Limit of Quantitation.

SF-4-312 03/18/98
Patrick AFB

| Sample | Methane | Ethylene | Ethane |
|---|---|---|---|
| 100ppm CH4 | 96.5 | ** | ** |
| 100ppm C2H4 | ** | 106.7 | ** |
| 100ppm C2H6 | ** | ** | 109.7 |
| HPHe | ** | ** | ** |
| Lab Blank | ** | ** | ** |
| CPT-12D | 7.64 | ** | 0.006 |
| CPT-86-16DD | 0.023 | ** | ** |
| CPT-18S | 4.09 | ** | ** |
| CPT-18MD | 7.56 | ** | ** |
| CPT-18DD | 0.030 | ** | ** |
| CPT-18DD Field Dup | 0.029 | ** | ** |
| 10ppm CH4 | 10.4 | ** | ** |
| 100ppm CH4 | 93.3 | ** | ** |
| 100ppm C2H4 | ** | 99.0 | ** |
| 100ppm C2H6 | ** | ** | 105.3 |

Lower Limit of Quantitation

| | Methane | Ethylene | Ethane |
|---|---|---|---|
| | 0.001 | 0.003 | 0.002 |

Units for the samples are mg/L dissolved in water.
Units for the standards are parts per million.

** denotes None Detected.
* denotes Below Limit of Quantitation.

Ref: 98-SH23

March 23, 1998

Dr. Don Kampbell
National Risk Management Research Laboratory
Subsurface Protection & Remediation Division
U.S. Environmental Protection Agency
P.O. Box 1198
Ada, OK 74820

THRU: S.A. Vandegrift SV

Dear Don:

Attached are TOC results for 13 Patrick liquids submitted March 19, 1998 under Service Request #SF-4-312. Sample analysis was begun March 19, 1998 and completed March 19, 1998 using RSKSOP-102.

Blanks, duplicates, and AQC samples were analyzed along with your samples, as appropriate, for quality control. If you have any questions concerning this data, please feel free to ask me.

Sincerely,

Sharon Hightower

Sharon Hightower

xc: R.L. Cosby
G.B. Smith
J.L. Seeley

KAMPBELL PATRICK SF-4-312

| SAMPLE | MG/L TOC |
|---|---|
| CPT-4D | 6.21 |
| CPT-4S | 5.23 |
| CPT86-3S | 30.7 |
| CPT86-3M | 24.2 |
| CPT86-3D | 11.9 |
| CPT18S | 6.82 |
| CPT18~~M~~ D | 6.47 |
| CPT18DD | 6.74 |
| CPT-86-16DD | 6.99 |
| MW-9 | 2.90 |
| CPT-9S | 3.12 |
| CPT-9D | 16.9 |
| CPT-12D | 12.4 |
| WS38 | 5.07 |

WS38 std t.v.=4.92

WATER QUALITY ANALYSES
PATRICK AIR FORCE BASE

| Sample | Date | D.O. | Redox | Conductivity | Fe# | $CO_2$ | Alkalinity | Sulfide | Manganese | pH | Temp |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Patrick AFB | ST-29 | mg/L | mV | µS/cm | mg/L | mg/L | mg/L | mg/L | mg/L | su | °C |
| CTP-4D | 3-9-98 | 0.1 | -286 | 497 | 0.2 | 70 | 200 | 5.0 | 0.1 | 8.0 | 25.4 |
| CPT-86-3D | 3-9-98 | 0.1 | -306 | N.D. | 0.1 | 75 | 260 | 5.0 | 0.1 | 7.2 | 25.5 |
| CPT-4S | 3-9-98 | 0.2 | -288 | 464 | <.1 | 70 | 220 | 3.0 | <.1 | 7.2 | 25.1 |
| CPT-3S | 3-9-98 | 0.0 | -313 | N.D. | 0.1 | 130 | 240 | 35. | 0.1 | 7.5 | 23.3 |
| CPT-18D | 3-9-98 | 0.0 | -110 | 260 | 0.1 | 100 | 340 | 0.1 | <.1 | 7.8 | 27.4 |
| CPT-86-3M | 3-9-98 | 0.0 | -276 | N.D. | 0.1 | 105 | 320 | 8.0 | <.1 | 7.0 | 24.4 |
| CPT-18M | 3-9-98 | 0.0 | -262 | 740 | 0.1 | 50 | 220 | 2.5 | <.1 | 7.5 | 26.1 |
| CPT-8S | 3-9-98 | N.D. | N.D. | N.D. | <.1 | 70 | 240 | 0.4 | <.1 | 7.8 | N.D. |
| CPT-86-16DD | 3-9-98 | 0.0 | -184 | N.D. | 0.2 | 110 | 360 | <.1 | 0.1 | 7.8 | 25.9 |
| MW-9 | 3-9-98 | 0.3 | -115 | N.D. | 0.1 | 50 | 130 | <.1 | <.1 | 7.6 | 21.9 |
| CPT-9D | 3-9-98 | 0.0 | -260 | 775 | <.1 | 70 | 320 | 2.0 | <.1 | 8.2 | 25.2 |
| CPT-9S | 3-9-98 | 0.0 | -234 | 312 | <.1 | 25 | 130 | 2.0 | <.1 | 7.2 | 24.2 |
| CPT-12D | 3-9-98 | 0.0 | -275 | N.D. | <.1 | 90 | 360 | 7.0 | <.1 | 7.8 | 26.0 |
| CPT-12S | No Sample Dry Well | | | | | | | | | | |